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Beck

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[54] **VIBRATION DAMPER FOR A MOTOR VEHICLE**

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5,042,624	8/1991	Furuya et al.	188/322.15 X
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[75] Inventor: **Hubert Beck, Eitorf, Germany**

[73] Assignee: **Fichtel & Sachs AG, Eitorf, Germany**

[21] Appl. No.: **389,344**

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[22] Filed: **Feb. 16, 1995**

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2500826	7/1976	Germany

Related U.S. Application Data

Primary Examiner—Lee W. Young

Attorney, Agent, or Firm—Nils H. Ljungman and Associates

[63] Continuation-in-part of Ser. No. 239,365, May 6, 1994.

[57] ABSTRACT

[30] Foreign Application Priority Data

A damping valve, in particular for a vibration damper for a motor vehicle, has a damping valve body with at least one admission channel for each direction of flow through the valve body. The admissions channel connects a top side and a bottom side of the damping valve body to one another. There can also be a valve plate on a valve seat surface, whereby the valve plate can lift up from the valve seat surface, and the admission channels from the top side and bottom side of the damping valve can have an initial choke inside the connection path. The cross section of the initial choke is defined by the width of an influx opening of the admission channel and the average radial distance between an edge, which determines the valve plate contour, and the inflow opening.

May 10, 1993	[DE]	Germany	43 15 458.1
May 10, 1993	[DE]	Germany	43 15 457.3
Feb. 16, 1994	[DE]	Germany	44 04 835.1

[51] **Int. Cl.⁶** **F16F 9/50**

[52] **U.S. Cl.** **188/282; 188/317; 188/322.15**

[58] **Field of Search** 188/299, 281, 188/282, 317, 319, 322.15, 322.14; 280/707, 714

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20 Claims, 13 Drawing Sheets

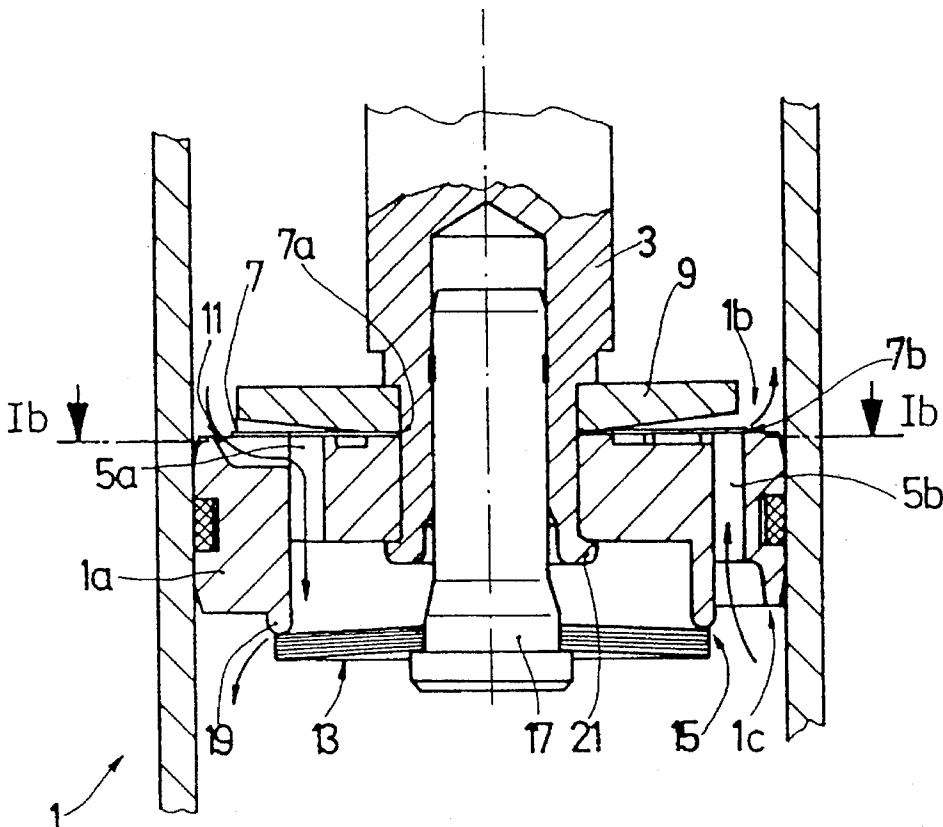


FIG. 1a

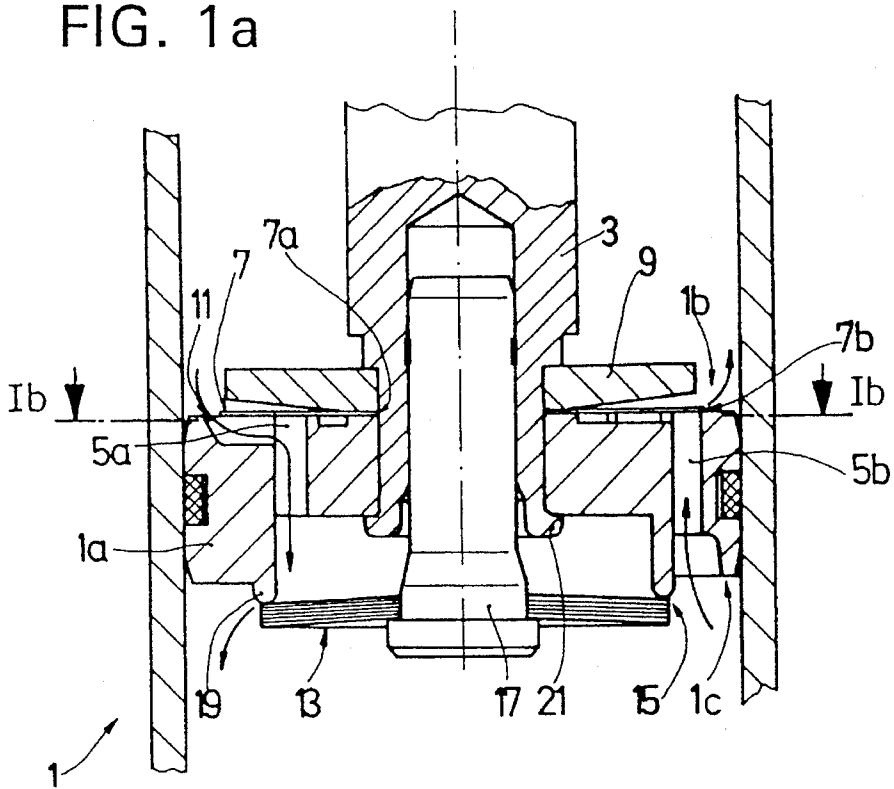


FIG. 1b

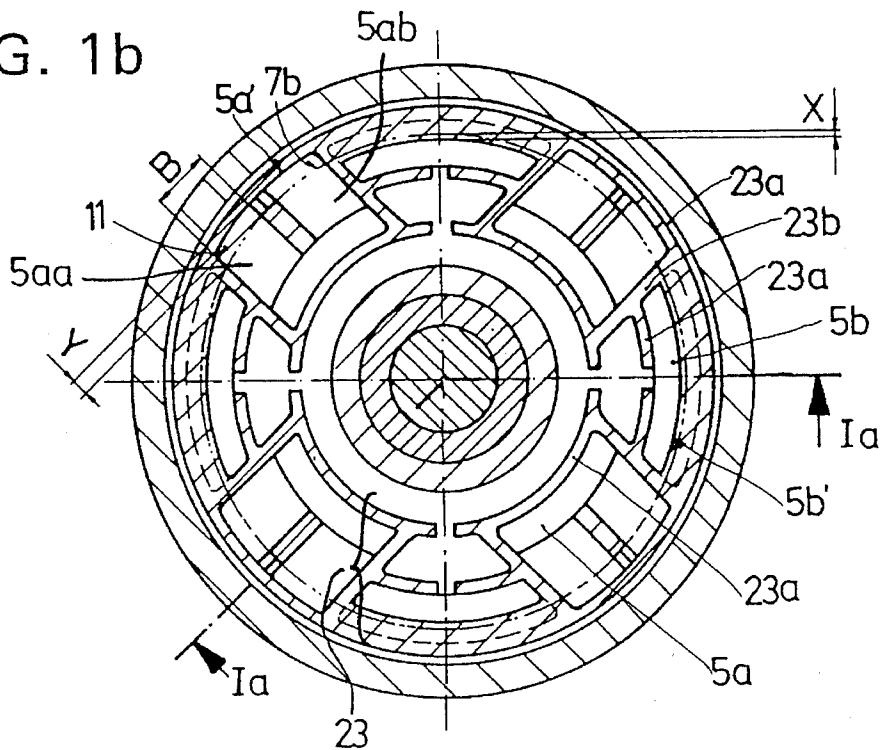


FIG. 2a

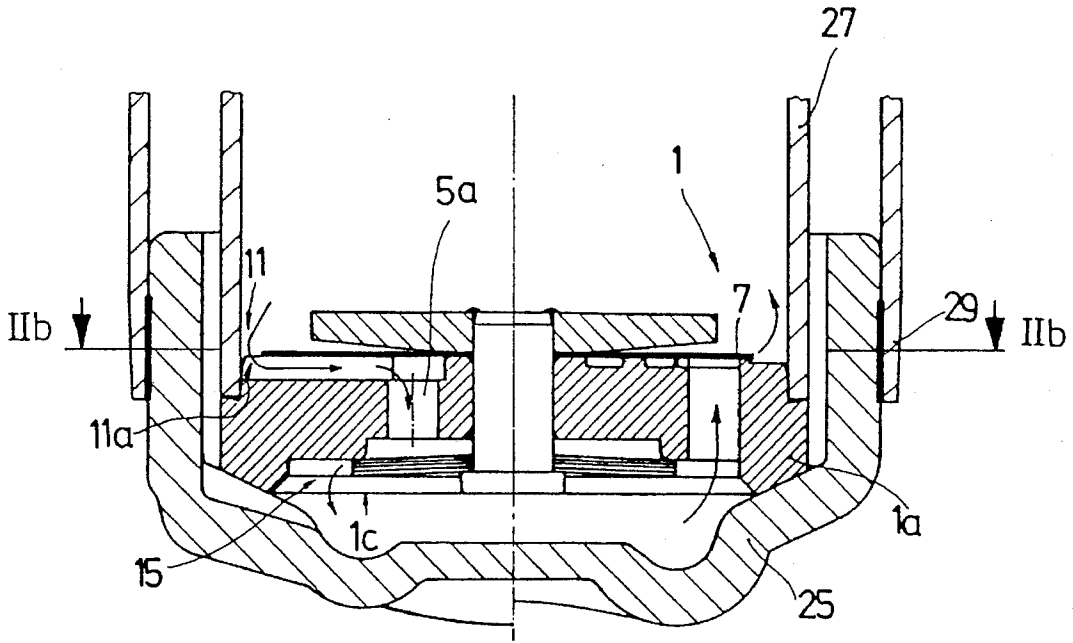


FIG. 2b

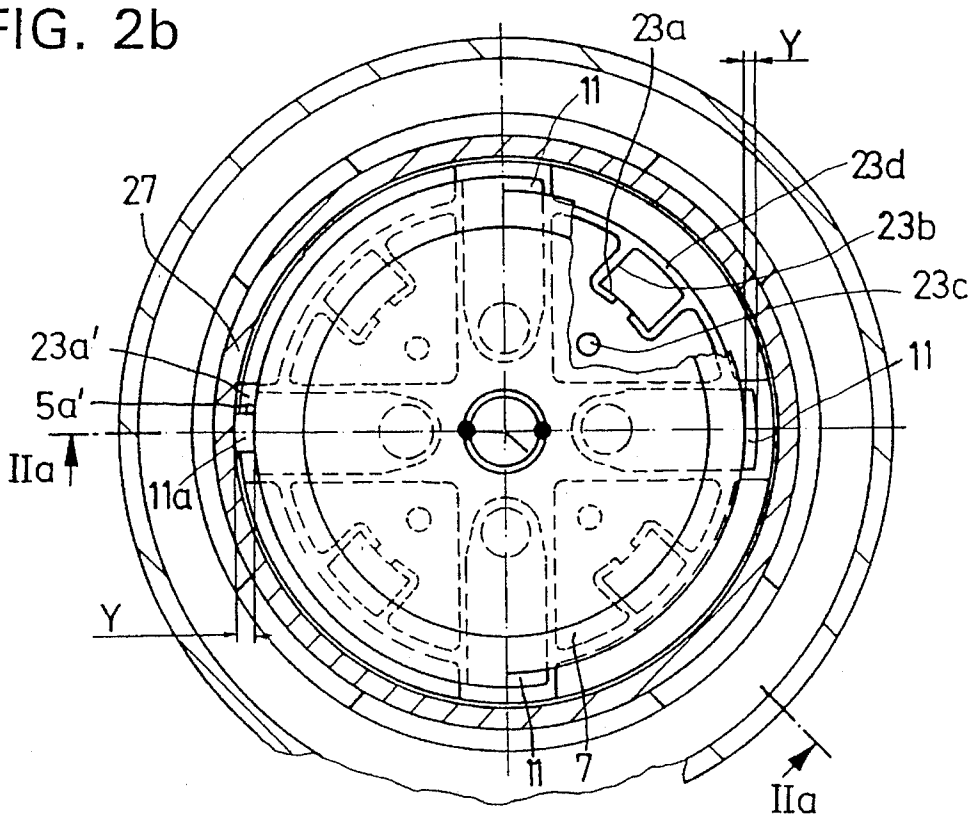


FIG. 3a

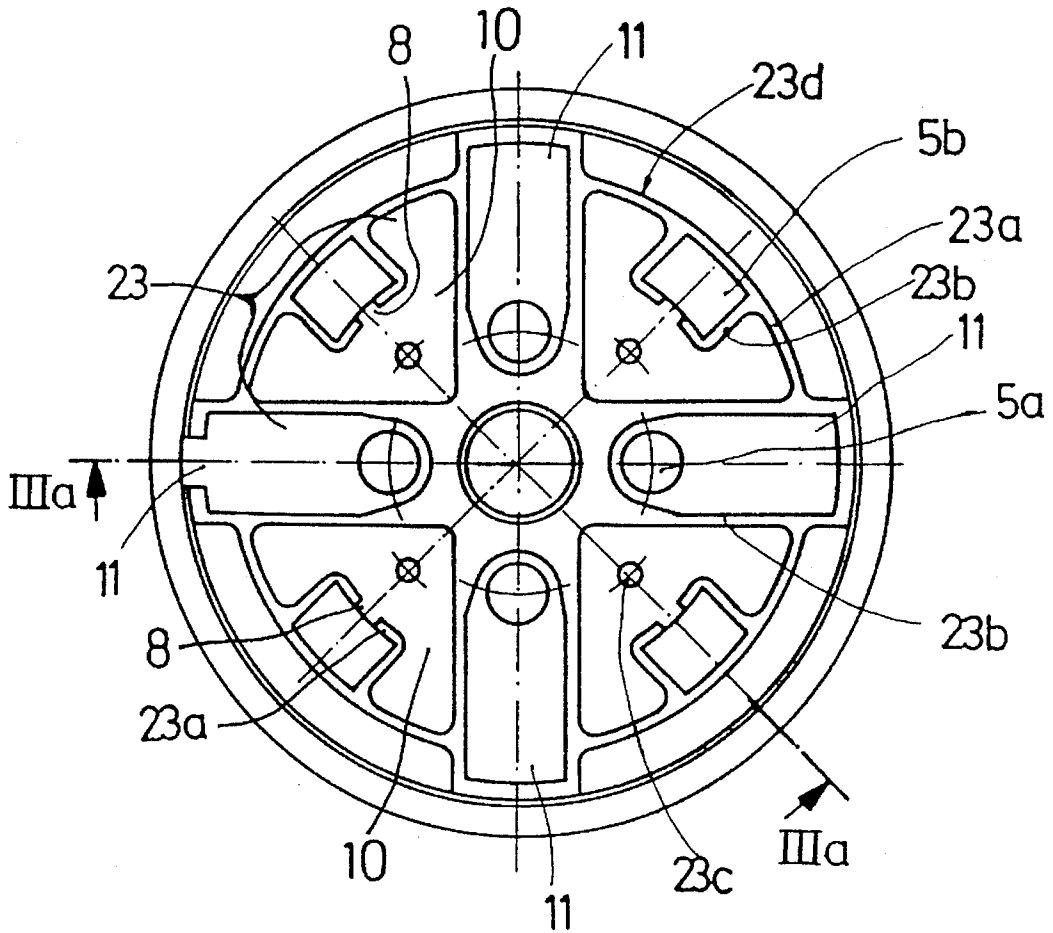
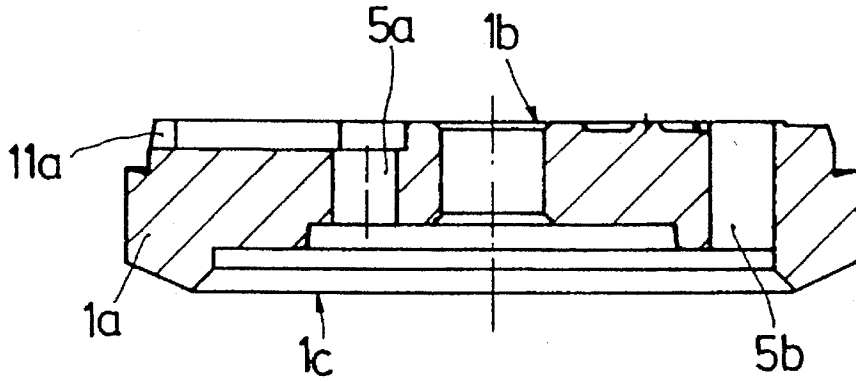


FIG. 3b

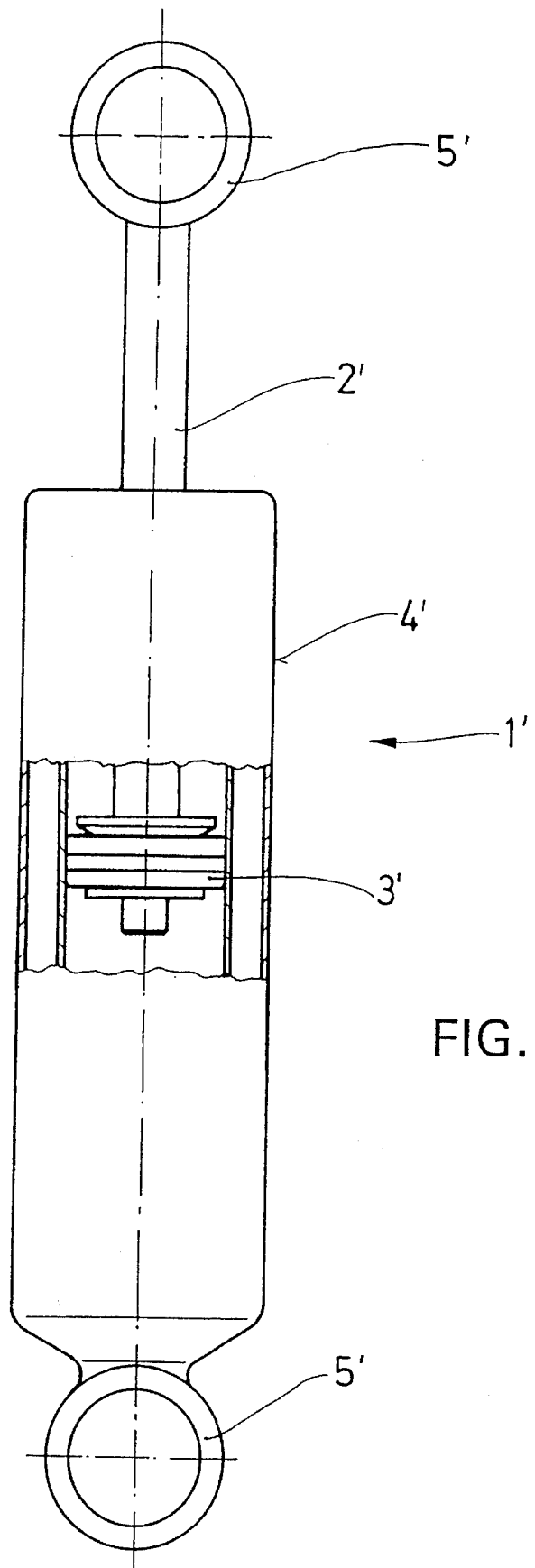


FIG. 4

FIG. 5

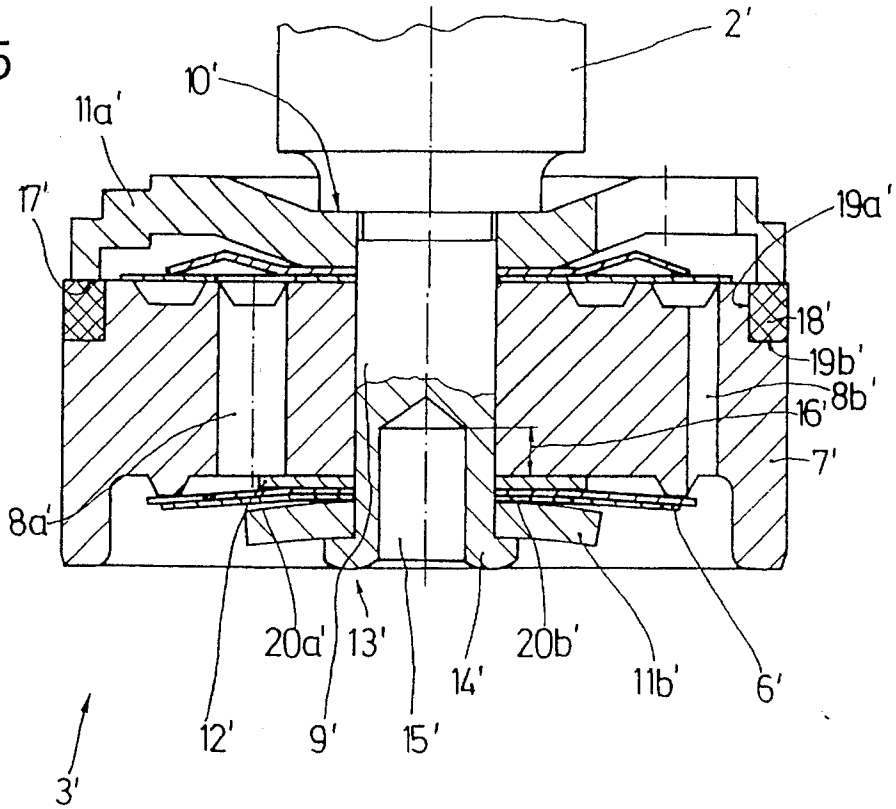


FIG. 5a

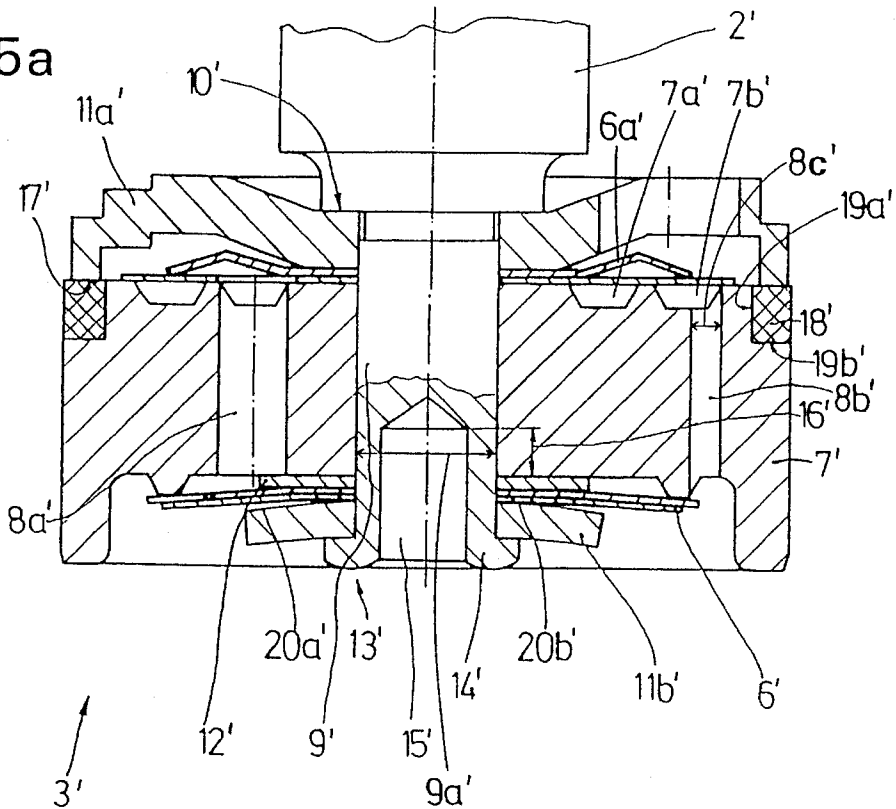


FIG. 6

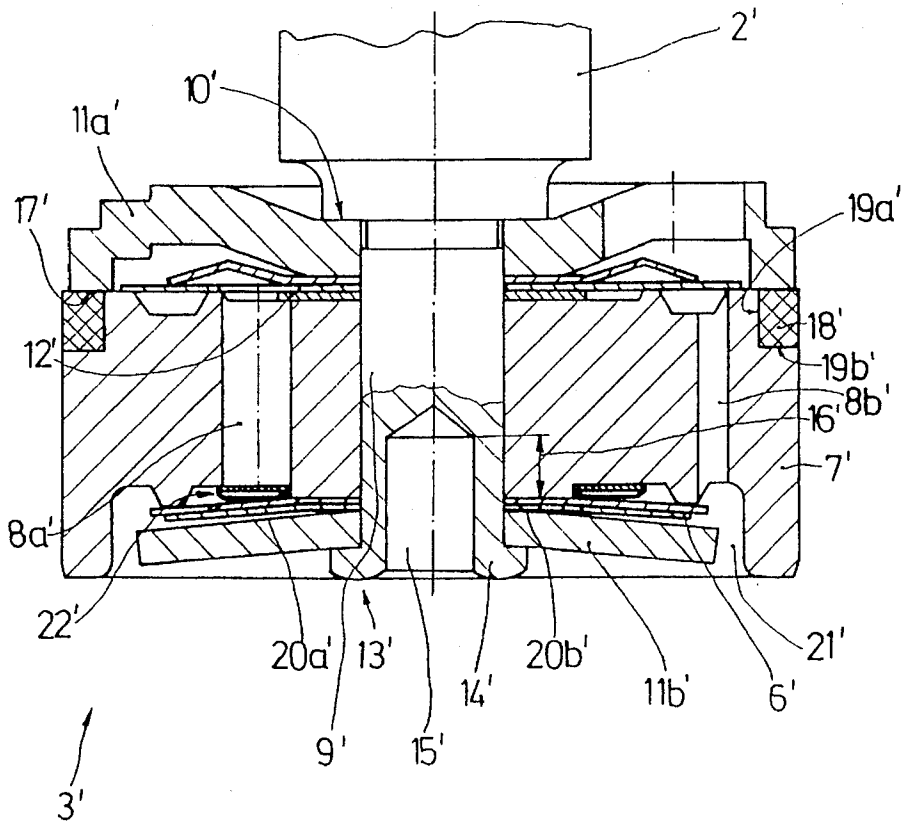


FIG. 6a

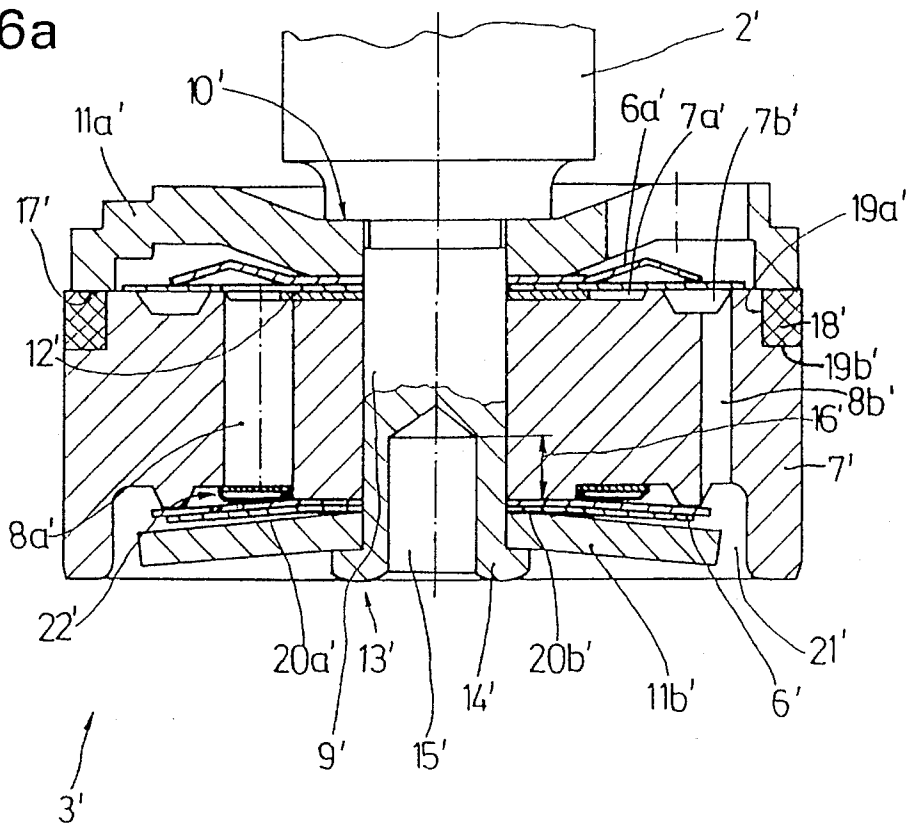


FIG. 7

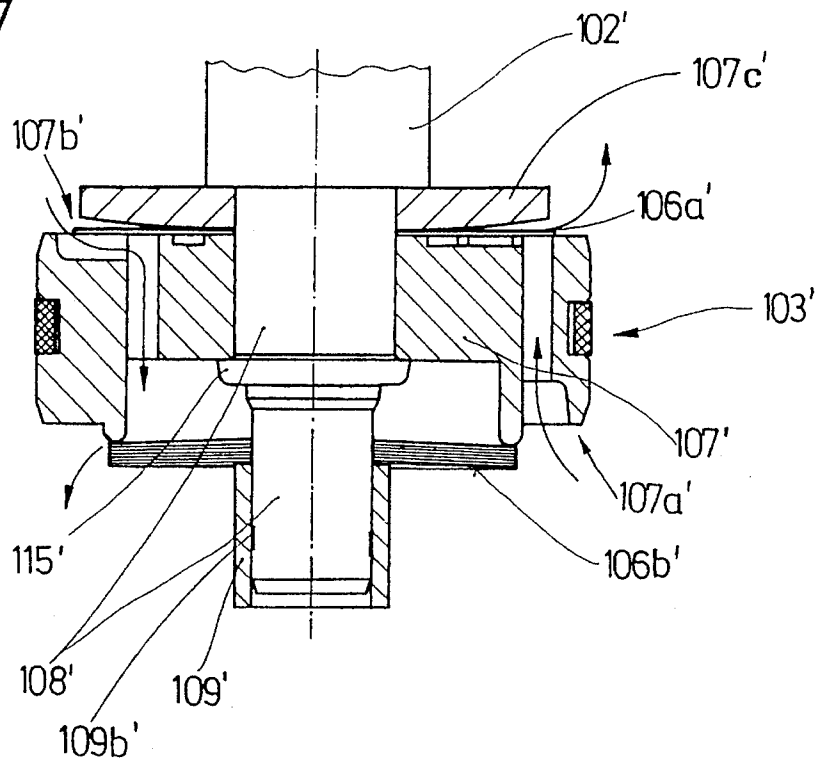


FIG. 7a

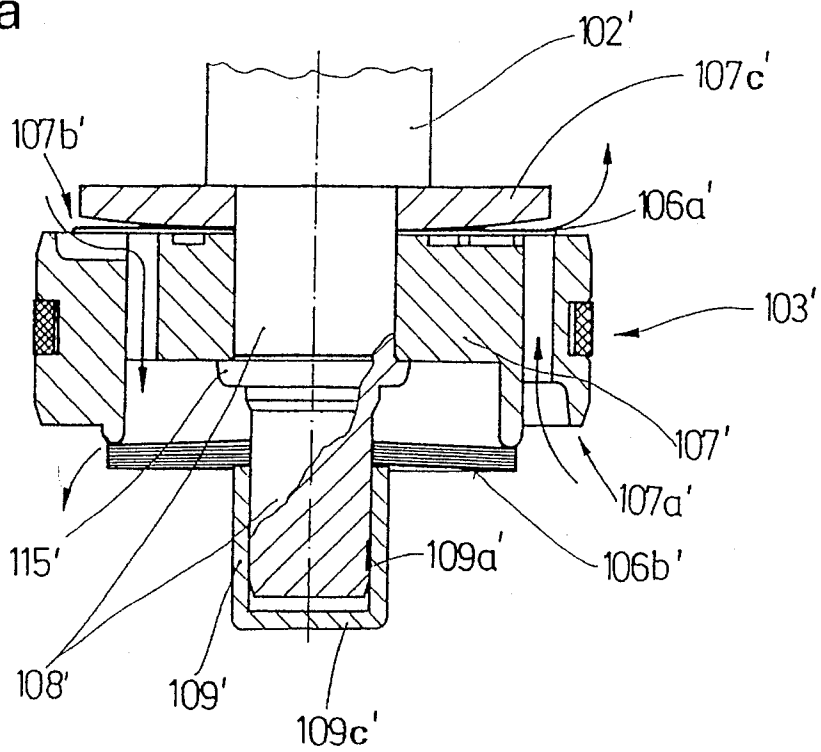


FIG. 8

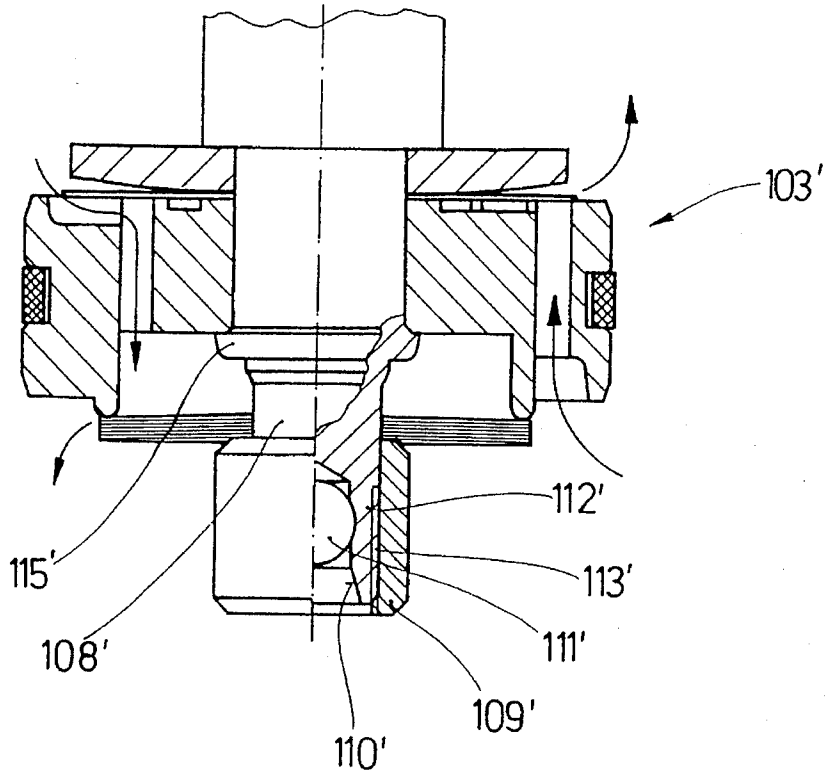


FIG. 8a

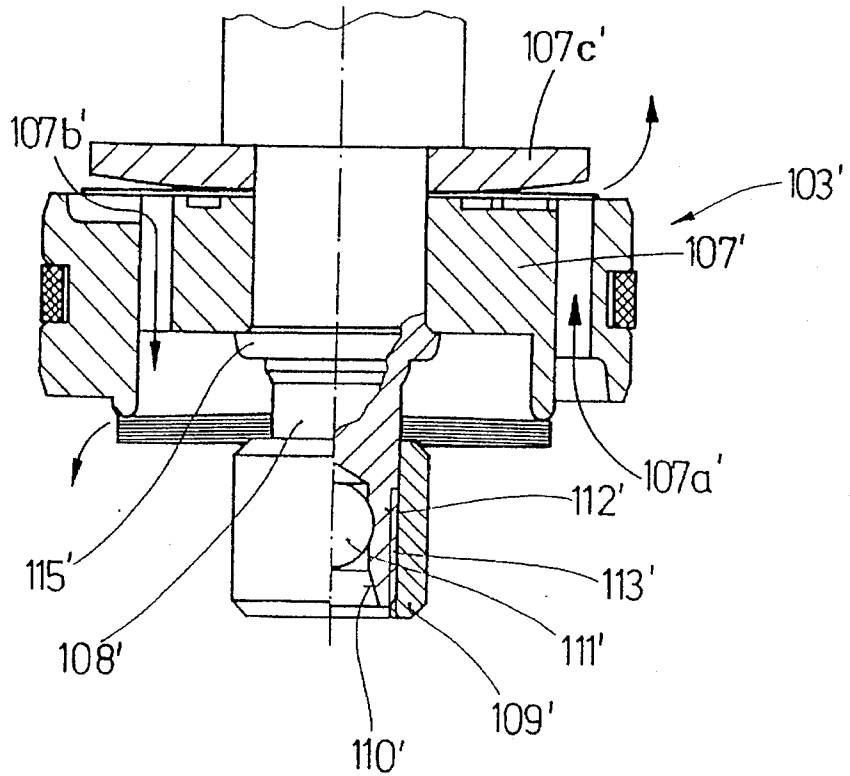


FIG. 9

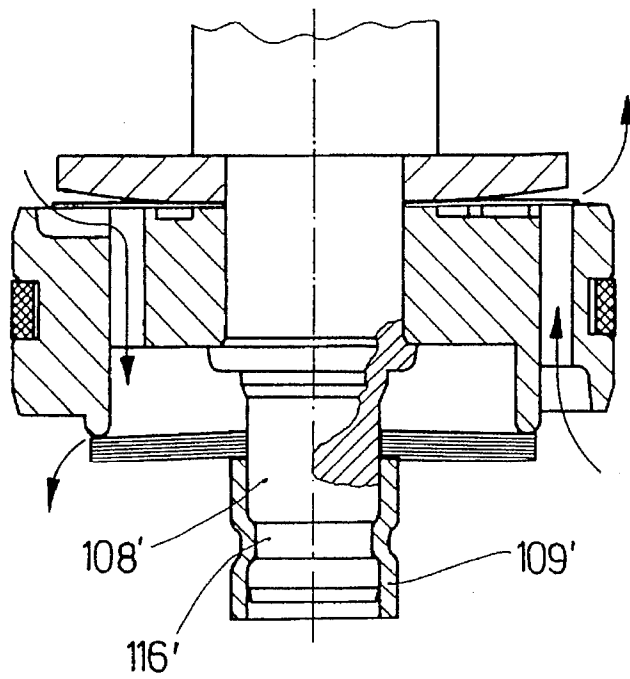


FIG. 9a

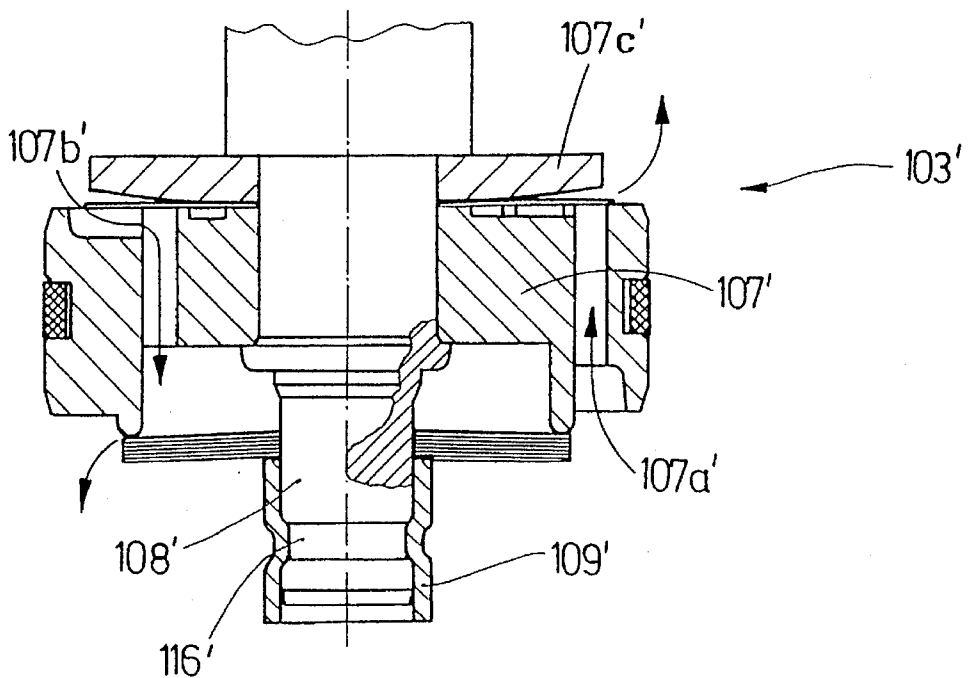


FIG. 10

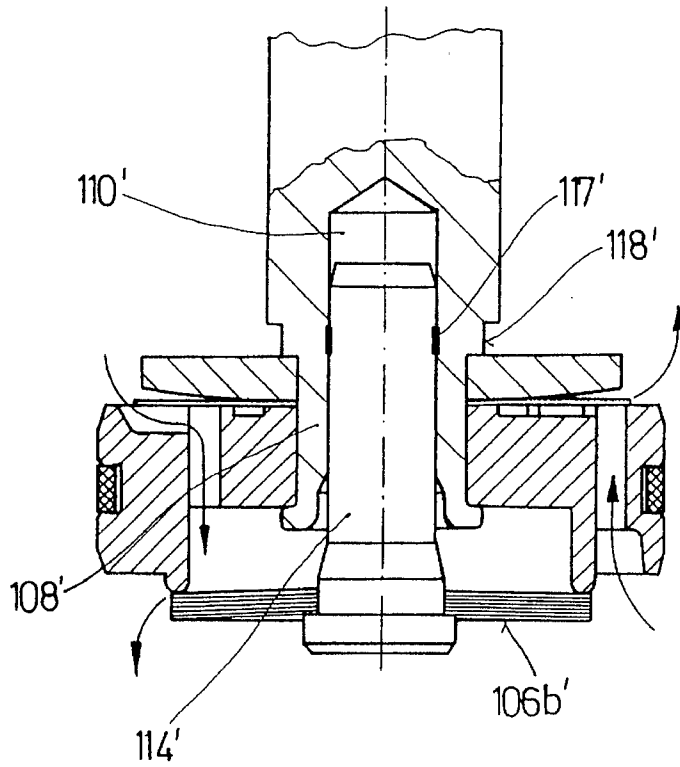


FIG. 10a

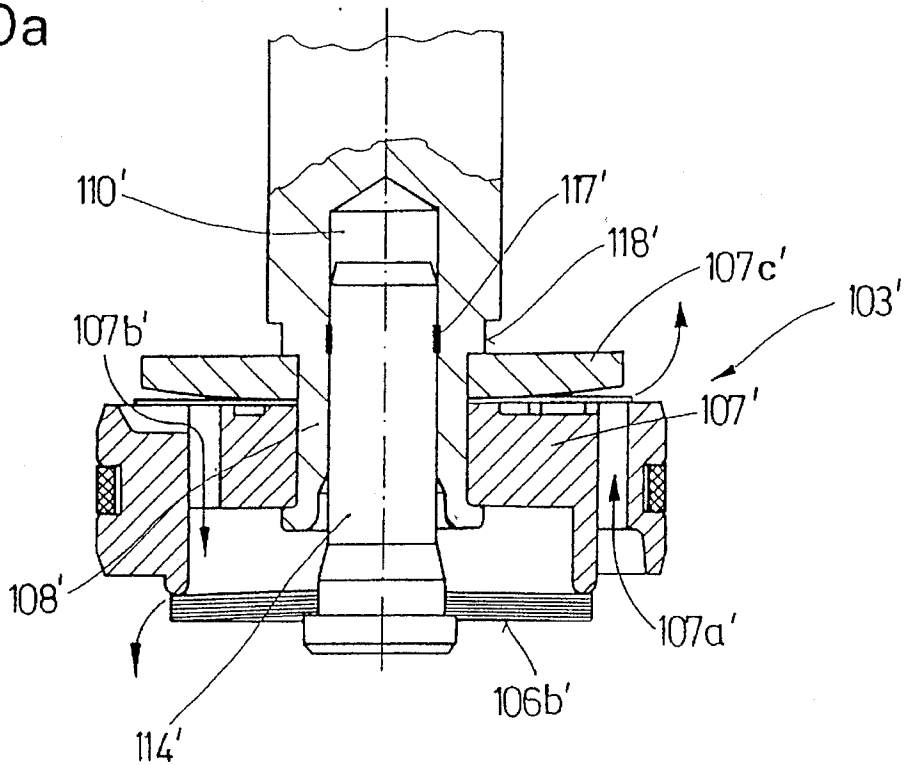


FIG. 11a

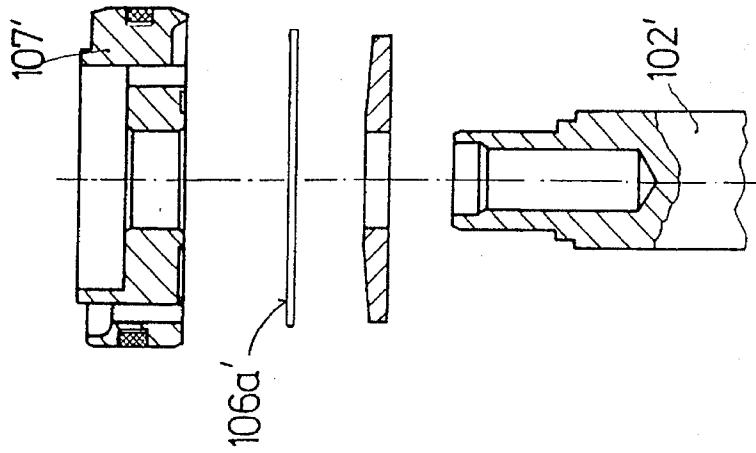


FIG. 11c

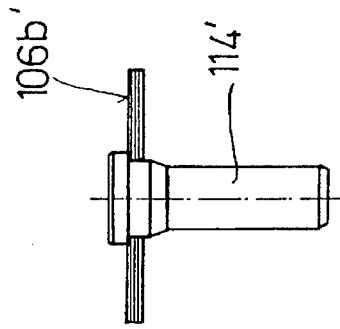


FIG. 11b

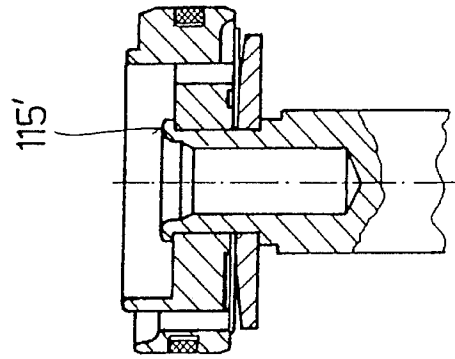


FIG. 11d

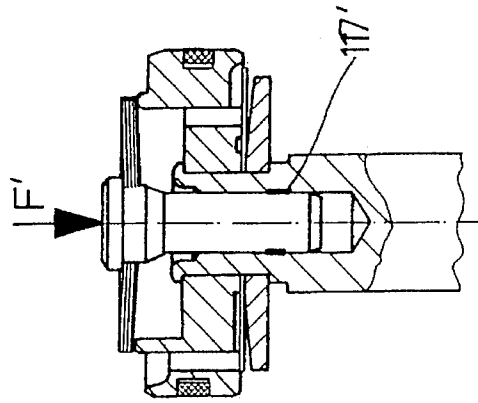


FIG. 12

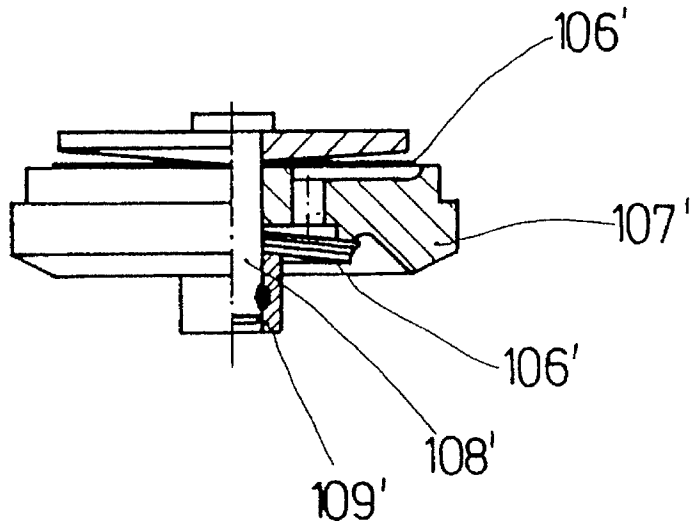


FIG. 12a

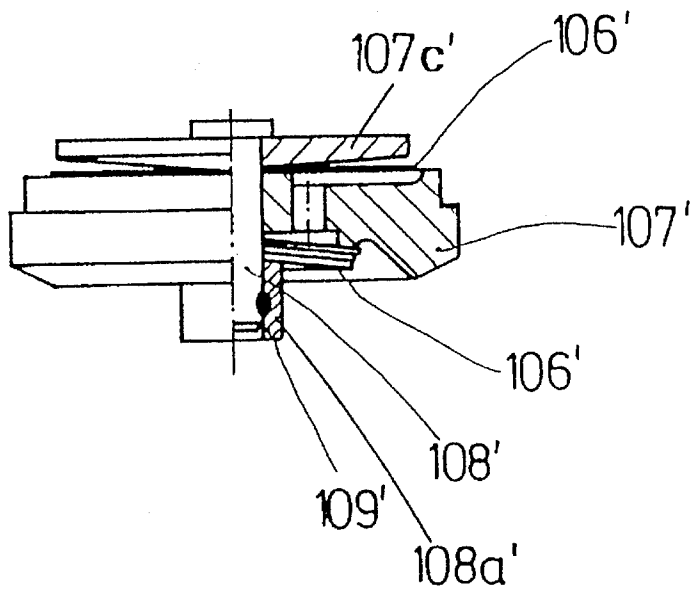
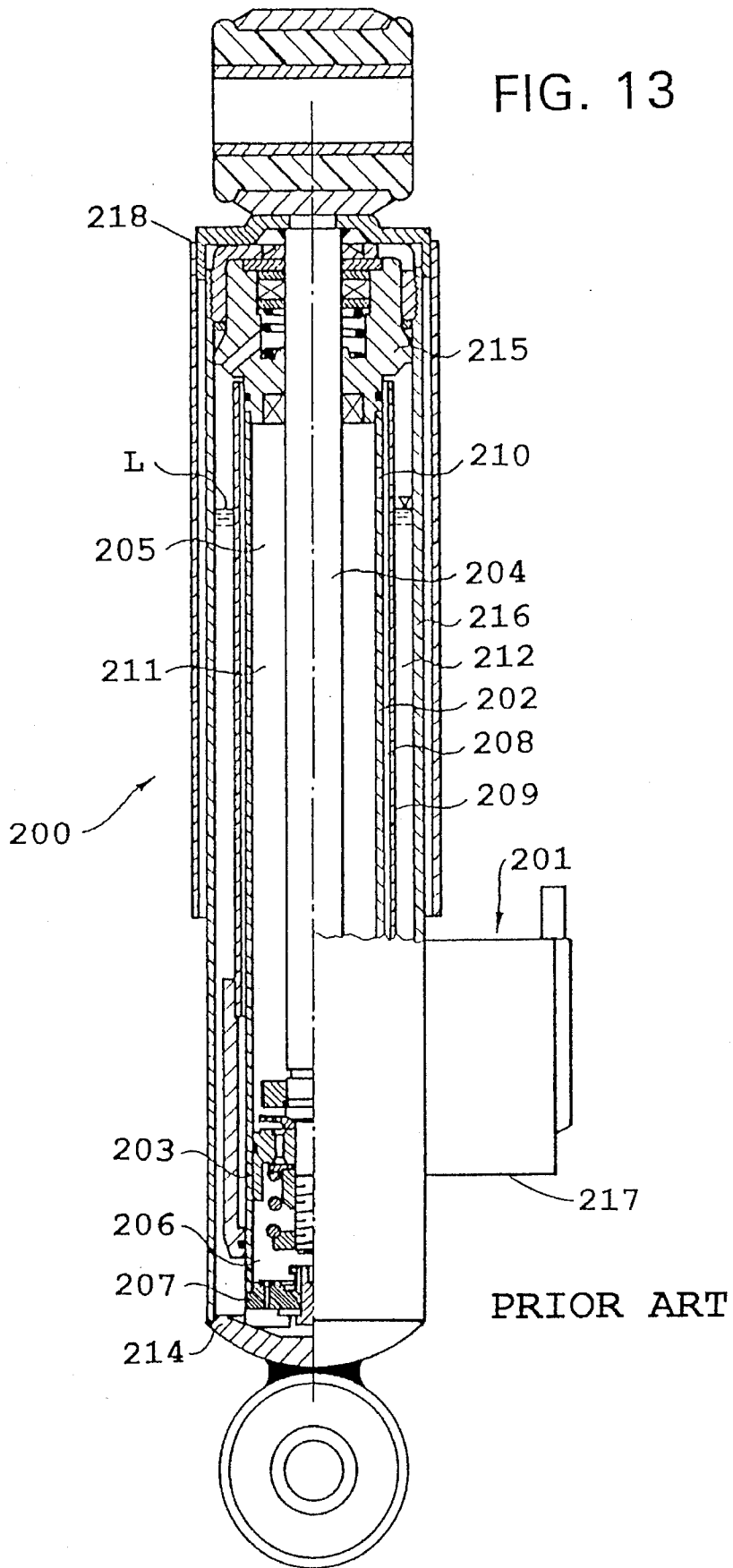


FIG. 13



VIBRATION DAMPER FOR A MOTOR VEHICLE

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of co-pending application Ser. No. 08/239,365, filed May 6, 1994, in the name of Andreas Förster, Andreas Sieber, Wolfgang Schu-
hmacher, and Hubert Beck, of which Hubert Beck is the
inventor herein, assigned to the assignee of the present
invention, and entitled "A Shock Absorber Having A Piston
Permanently Attached To Its Piston Rod", which application
is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a vibration
damper for a motor vehicle, which vibration damper can
typically have a cylinder defining a substantially fluid filled
chamber therewithin. A piston rod generally extends into the
chamber through one end of the cylinder, and the piston rod
preferably has a piston disposed thereon, which piston
divides the chamber into two chamber portions. The cham-
ber portion into which the piston is pushed during the
insertion of the piston rod into the cylinder can be called the
"compression" chamber, while the other chamber portion
can be called the "rebound" chamber. In order to provide at
least a portion of the damping function of the vibration
damper, the piston can have fluid passages disposed there-
through and interconnecting the two chamber portions,
whereby fluid flow through the passages is controlled by
means of a damping valve.

More particularly, the present invention relates to a damp-
ing valve having a valve body with at least one admission
channel, or flow passage for each direction of flow of fluid
between the two chamber portions. Such admission channels
essentially connect a top side and a bottom side of the
damping valve body to one another. To provide a valve
function, there can be a valve plate on a valve seat surface,
whereby the valve plate can lift up off the valve seat surface
in essentially one direction of flow, while in the opposite
direction of flow, the valve plate can be pressed against the
valve seat to close the passage. For the fluid flow passages
permitting fluid to flow from the "rebound" chamber to the
"compression" chamber, generally from the top side to the
underside of the damping valve, there can preferably be a
restriction for limiting the flow of fluid therethrough, or in
other words, there can be a choke in the passage.

2. Background Information:

German Laid Open Patent Application No. 25 00 826,
discloses valve designs of the general type as set forth
above. In the valves disclosed therein, a relatively thick
valve cover plate covers a ring groove having an internal
contour. During assembly operations, this component must
still be fed to the robot by hand.

Other known valve designs include coil spring valves of
this type, in which valves the choke for the opposite damp-
ing valve is realized in the form of an additional disc inside
the damping valve. In such a case, the use of a standard valve
body which is already provided with non-choke openings is
advantageous, because it makes it possible to standardize the
damping valve. But the additional component which has the
throttle openings and the above-mentioned weak points
represents a disadvantage.

Unexamined French Patent Application FR-OS 2 061 905
discloses a valve with a very simple construction. The valve
body consists of sheet metal, whereby all the holes are
introduced by punching. The thin valve cover disc is pen-
etrated by holes on an inside arc. The valve cover disc can
be provided with a variable number of holes. But this valve
disc is extraordinarily disadvantageous, since it must be
installed in a defined position in relation to the valve body.
The installation must once again be performed manually,
since the disc does not have a design with a symmetry of
rotation which would make it suitable for fully-automatic
assembly operations. Because there are holes in the area of
the maximum stresses, the durability of the component is
severely restricted. There also exists a risk that the valve disc
can twist out of position in relation to the valve body, either
during the assembly process or during operation, and can
result in at least a reduction of the passage cross section, if
not a hydraulic blockage.

OBJECT OF THE INVENTION

The object of the present invention is therefore to create
a damping valve which makes possible a standard valve
body which can be used in a large number of models of
damping valves, has a low weight of the moving parts of the
valve for a good dynamic characteristic, and contains only
individual parts which have symmetry of rotation, thereby
making it possible for fully-automatic assembly. It is also an
object of the present invention to provide a damping valve
which generally has a low number of parts. In addition, the
present invention teaches that the parts themselves can be of
an extraordinarily simple design.

SUMMARY OF THE INVENTION

The present invention teaches that this object can be
accomplished if the cross section of the choke of the valve
passages has dimensions which are preferably defined by the
width of an inflow opening of the admission channel and the
average radial distance between a radial edge which defines
the contour of the valve plate, and an outer radial edge of the
inflow opening. A standard, and thereby preferably uniform
valve body can then preferably be advantageously used for
many different damping valves, wherein the size of the
choke can be dictated by the diameter of the valve plate.

In addition, since the valve plates can essentially be
manufactured as individual components with extreme pre-
cision and at a very low cost, the cross sections of the choke
openings of a large number of valves are subject to only a
small range of variation. Thus, there can essentially be only
a small difference in the damping force among the large
number of mass-produced valves.

An additional advantageous feature of at least one
embodiment of the present invention provides that the
inflow opening can preferably be located in the vicinity of
the outside diameter of the damping valve body. As such, the
outside diameter of the valve plate can essentially define the
choke cross section. Consequently, since the arc on which
the chokes are located is large, large choke cross sections
can be achieved. In a related manner, the influences of the
dimensions which determine the choke, in particular the
outside diameter of the valve plate, are further reduced, as
variations in the dimensions can thus have less effect on the
overall opening than the same variations would tend to have
on a small cross section.

3

In an additional advantageous configuration of at least one embodiment of the present invention, the valve plate can preferably be designed elastically as a solid disc, and can thereby be fixed or mounted by means of the inside diameter. Such a disc represents an extremely economical individual component. Because the disc can preferably be solid, the disc can also essentially be relatively thin. As such, the weight of the disc will typically not influence the functional capabilities of the damping valve, and the durability of the component can thus essentially be guaranteed.

An additional advantageous feature provided by at least one additional embodiment of the present invention is that the valve seat surface can preferably be formed by a web labyrinth system. Such a web labyrinth system can serve to separate the admission channels of the two flow directions from one another, while also essentially making it possible to have very large areas of the valve plate which are pressurized when there is flow of fluid through the valve body to the valve body side of the plate. Moreover, since the web labyrinth system essentially minimizes surface contact between the valve plate and the valve body, there are no large contact surfaces on the valve plate which could result in the valve plate sticking to the surface of the valve seat.

Such a web labyrinth system can essentially advantageously have a number of concentrically oriented web segments, whereby there are additional web segments which run radially to separate the admission channels for the different directions of flow. The web labyrinth system, in addition to the formation of the largest possible pressurized surfaces for the valve disc, is also optimized to limit the deflection of the valve plate to a minimum with a small valve seat contact surface.

An additional feature provided by at least one additional embodiment of the present invention is that the damping valve can be provided with a multiplicity of such chokes. In a still further embodiment of the present invention, the largest choke cross section can be formed when the outside diameter of the valve plate is reduced to a point where the outside diameter essentially comes into contact with the outermost circumferential web area for the discharge side for the reverse direction of flow. The web labyrinth system can also advantageously have a radial opening which acts as the choke.

In a further embodiment of the present invention, the cross sections of at least two chokes can advantageously be of different sizes. As a result of this advantageous feature, the bandwidth, or tolerance of the outside diameter of the valve, can be kept small. The admission channels can also preferably be designed so that they are disposed very close to one another within the valve body, without there being a danger of any hydraulic short circuit. In essence, such a short circuit would occur if the damping medium were to bypass the valve disc wherein there would be communication between the admission channels. Only the contact surfaces for the valve disc, which contact surfaces also separate the directional flow passages from one another, are dimensionally limited.

Such a valve as set forth hereabove can essentially be assembled and secured fully automatically with a short cycle time, thus, eliminating the disadvantages of the valves utilized in the past. The assembly can essentially be accomplished by fastening at least some of the valve discs and the valve body on the journal, or piston rod, etc. by means of an essentially non-detachable positive fit, which may alternatively be termed a "deformation fit" or a "force fit".

All the disadvantages of a threaded connection used in the past can essentially be eliminated by the non-detachable

4

positive fit. Likewise, there are essentially no adjustment problems for the valve damping force, since the effect of friction inside the above-referenced threaded connection is preferably essentially eliminated.

5 To prevent the formation of chips from cutting or machining processes, one advantageous feature of the present invention is that the fastening is preferably a positive fit and/or a weld joint. Such a valve construction can preferably be installed essentially without problems in a piston, and also as a bottom valve in the shock absorber.

10 The present invention also teaches that the positive fit is preferably formed by the journal. According to an additional advantageous feature of the present invention, the journal preferably has a blind hole, so that a ring wall is formed which ring wall preferably has an overhang in relation to the valve discs and valve body threaded onto it, whereby the overhang can preferably form the positive fit by means of a bead. There is also advantageously an overlap between the blind hole and the valve body. Thus, a bearing force can be achieved which causes an additional axial force, but also essentially eliminates the play which can be present, under some circumstances, between the valve body and the journal.

25 So that the valve discs cannot be damped uncontrollably, there is preferably at least one supporting ring for the valve discs located inside the row of components axially braced in line. In an additional advantageous embodiment of the present invention, the supporting ring preferably has a rolling contour, so that the damping occurs according to a desired behavior. For example, in one advantageous configuration, the rolling contour can be formed by two connected, essentially conical surfaces. The result is a damping force characteristic which is preferably graduated.

30 To reduce the manufacturing costs for the valve body, in the function of a piston valve, the piston ring is fastened to the valve body preferably without undercutting. The use of a sintered valve body can also result in major advantages in terms of the sintering dies. For a valve body made of sheet metal, the deforming expense can also essentially be reduced. To increase the allowable axial load of the piston ring, one supporting ring preferably has a fastening surface for the piston ring.

35 An additional advantageous feature of the present invention is that the supporting ring, with its fastening surface, can preferably be partly supported on the end face of the valve body. The piston ring is thereby preferably excluded from the row of axially braced components of the valve in terms of tolerances.

40 In an additional configuration, the valve discs facing the piston rod and the valve body are preferably fixed axially.

45 From a manufacturing point of view, an advantage of the present invention when incorporated on the piston of a shock absorber, is that the cylindrical component is preferably a component of the piston rod. The piston rod can thereby be provided with a journal in the vicinity of its piston, so that this journal can be used for the axial threading of the valve discs and valve body.

50 One characterizing feature of the present invention is that the cylindrical component is preferably provided with a hole, in which a cylindrical component provided with the valve discs is fastened.

55 To preferably achieve a positive fit by a non-cutting, forming operation, in one embodiment of the present invention, the cylindrical component is preferably surrounded by the fastening element, and the cylindrical component is expanded from inside to outside.

According to an additional characterizing feature of the invention, the expansion of the cylindrical component is preferably accomplished by means of an expander element located in a hole of the cylindrical component. A sphere can be advantageously used as the expander element.

To further improve the positive fit, preferably between the fastening element and the cylindrical component, the cylindrical component and/or the fastening element is/are provided, preferably on the surfaces facing one another, with at least one projection and/or one recess. The projection and/or the recess preferably run in an annular fashion over the entire circumference.

In an additional configuration, the fastening element is preferably made of light metal or a light metal alloy, and the fastening element is preferably shrink-fitted onto the cylindrical component in an essentially contactless manner by electrically pulsed magnetic fields.

It should be understood that when the word "invention" is used in this application, the word "invention" includes "inventions", that is, the plural of "invention". By stating "invention", Applicant does not in any way admit that the present application does not include more than one patentably and non-obviously distinct invention, and maintains the possibility that this application may include more than one patentably and non-obviously distinct invention. The Applicant hereby asserts that the disclosure of this application may include more than one invention, and, in the event that there is more than one invention, that these inventions may be patentable and non-obvious, one with respect to the other.

One aspect of the invention resides broadly in a vibration damper for damping vibrations of a motor vehicle, the vibration damper comprising: a first tubular member, the first tubular member comprising first apparatus for attaching the first tubular member to one of: a wheel suspension and a support structure of the motor vehicle; the first tubular member defining a first chamber therewithin, the first chamber comprising damping fluid therewithin, and the first tubular member defining a longitudinal dimension; piston rod apparatus, the piston rod apparatus having a first end within the first tubular member and a second end external to the first tubular member, the piston rod apparatus being movable within the first tubular member in a direction along the longitudinal dimension of the first tubular member; apparatus for attaching the second end of the piston rod apparatus to the other of: the wheel suspension and the support structure of the motor vehicle; piston apparatus disposed at the first end of the piston rod apparatus, the piston apparatus having a first side disposed adjacent the piston rod apparatus and a second side opposite to the first side, and the piston apparatus dividing the first chamber into a first chamber portion adjacent the first side thereof and a second chamber portion adjacent the second side thereof; the piston apparatus comprising: at least one first passage for permitting fluid flow in one direction from the first chamber portion to the second chamber portion, the first side of the piston apparatus comprising a passage opening of the at least one first passage for permitting fluid flow from the first chamber portion into the first passage, the passage opening comprising a constant opening for permitting fluid flow from the first chamber into the at least one first passage, the passage opening having an outer periphery disposed towards the first tubular member and a radially inner edge disposed radially inwardly of the outer periphery; at least one second passage for permitting fluid flow from the second chamber portion to the first chamber portion, the first side of the piston apparatus comprising a valve seat for the at least one second passage; a flexible plate disposed at the first side of

the piston apparatus, the flexible plate being configured for bending away from the valve seat to open the second passage upon fluid pressure in the second chamber portion being greater than fluid pressure in the first chamber portion, and the flexible plate being configured for sealing against the valve seat to block flow of fluid through the second passage from the first chamber portion to the second chamber portion, the flexible plate having a peripheral edge disposed towards the first tubular member; and the outer peripheral edge of the flexible plate defining the radially inner edge of the passage opening of the at least one first passage.

Another aspect of the invention resides broadly in a valve for damping fluid flow within a vibration damper of a motor vehicle, the vibration damper comprising a first tubular member, the first tubular member comprising first apparatus for attaching the first tubular member to one of: a wheel suspension and a support structure of the motor vehicle; the first tubular member having a first end and a second end and defining a first chamber therewithin, the first chamber comprising damping fluid therewithin, and the first tubular member defining a longitudinal dimension; piston rod apparatus, the piston rod apparatus having a first end within the first tubular member and a second end extending through the second end of the first tubular member, the piston rod apparatus being movable within the first tubular member in a direction along the longitudinal dimension of the first tubular member; apparatus for attaching the second end of the piston rod apparatus to the other of: the wheel suspension and the support structure of the motor vehicle; piston apparatus disposed at the first end of the piston rod apparatus, the piston apparatus having a first side disposed adjacent the piston rod apparatus and a second side opposite to the first side, and the piston apparatus dividing the first chamber into a first chamber portion adjacent the first side thereof and a second chamber portion adjacent the second side thereof; a second tubular member disposed concentrically about the first tubular member, the second tubular member defining a second fluid chamber between the first and second tubular members; the vibration damper comprising at least one damping valve for at least one of: damping fluid flow between the first and second chamber portions, and damping fluid flow between the first and second chambers, the damping valve comprising: a valve body, the valve body having a first side and a second side; at least one first passage for permitting fluid flow in one direction from the first side of the valve body to the second side of the valve body, the first side of the valve body comprising a passage opening of the at least one first passage for permitting fluid flow from the first side of the valve body into the first passage, the passage opening comprising a constant opening for permitting fluid flow from the first side of the valve body into the at least one first passage, the passage opening having an outer periphery and a radially inner edge disposed radially inwardly of the outer periphery; at least one second passage for permitting fluid flow from the second side of the valve body to the first side of the valve body, the first side of the valve body comprising a valve seat for the at least one second passage; a flexible plate disposed at the first side of the valve body, the flexible plate being configured for bending away from the valve seat to open the second passage upon fluid pressure at the second side of the valve body being greater than fluid pressure at the first side of the valve body, and the flexible plate being configured for sealing against the valve seat to block flow of fluid through the second passage from the first side of the valve body to the second side of the valve body, the flexible plate having an outer peripheral edge; and the outer peripheral edge of the

flexible plate defining the radially inner edge of the passage opening of the at least one first passage.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is explained below in greater detail, with reference to the accompanying drawings, in which:

FIGS. 1a and 1b respectively show cross sectional and overhead views of a damping valve on a piston rod;

FIGS. 2a and 2b respectively show cross sectional and overhead views of a damping valve in an embodiment as a base valve;

FIGS. 3a and 3b respectively show cross sectional and overhead views of a damping valve body as an individual part;

FIG. 4 shows a shock absorber, partly in cross section and partly in a plan view;

FIGS. 5 and 6 show a piston of a shock absorber in cross section;

FIGS. 5a and 6a show substantially the same views as FIGS. 5 and 6, respectively, but show additional components;

FIGS. 7-10 illustrate various pistons of a shock absorber in cross section;

FIG. 7a shows an additional embodiment of a piston similar to that shown in FIG. 7;

FIGS. 8a, 9a, and 10a show substantially the same views as FIGS. 8-10, but show additional components;

FIGS. 11a-11d illustrate the sequence of assembly of one realization of a piston;

FIG. 12 illustrates a bottom valve of a shock absorber, partly in cross section and partly in a plan view;

FIG. 12a shows substantially the same view as FIG. 12, but shows additional components; and

FIG. 13 shows a typical shock absorber in which the embodiments of the present invention could be incorporated.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1a and 1b show a damping valve 1 of a piston rod 3, as could conventionally be used in a vibration damper as depicted in FIGS. 4 and 13. As shown, the damping valve 1 can generally have a damping valve body 1a. The damping valve body 1a can preferably have at least one fluid flow passage, or admission channel 5a, 5b for each direction of flow of fluid through the valve body 1. Each of these admission channels 5a, 5b preferably connects one side 1b of the damping valve body 1a to another side 1c. In a vertically arranged vibration damper, i.e., as shown in FIGS. 4 and 13, the side 1b can generally be the top side, while the side 1c can be the underside. Alternatively, if the vibration damper orientation as shown in FIGS. 4 and 13 were to be reversed, the designations given above would also be reversed.

On at least one side of the body 1a, in this embodiment the top side 1b, there can preferably be a valve plate 7 which can be firmly fixed by means of its inside diameter 7a. In other words, the valve plate 7 can essentially be held in place by means of its inner area, or area disposed about the inside diameter 7a. This valve plate 7 essentially covers the admission channel 5b (or admission channels 5b, when more than one are provided as shown in FIG. 1b). The channels 5b are the channels which have their discharge cross section on the top side 1b of the valve body 1a. Thus, the valve plate 7 can

essentially provide the function of a non-return, or check valve.

With such a valve plate 7, the valve plate 7 can thereby preferably be designed as a solid, circular, ring-shaped disc mounted immediately adjacent the valve body 1a. When there is a fluid pressure from the underside 1c, the valve plate 7 can preferably be deflected upwardly to open the passage 5b. The opening movement of the valve plate 7 upwardly is preferably limited by a support plate 9. As such, when a maximum opening position has been reached by the valve plate 7, the valve plate 7 can preferably be supported on the support plate 9. To adapt the damping valve to have different damping valve characteristics, the standard damping valve body 1a can be very easily equipped with valve plates 7 of different thicknesses and rigidities, to thereby make the opening characteristics harder with stiffer plates, or softer with more flexible plates.

For the reverse direction of flow, i.e. from the top side 1b of the damping valve 1 to the underside 1c of the damping valve 1, there is preferably the admission channel 5a and a valve 15, which valve 15 preferably is formed by at least one valve disc 13 fixed to the underside 1c of the damping valve 1. The valve plate 7 can essentially cover at least a portion of the corresponding admission channel 5a, because of the circular dimensions of the valve plate 7. As such, the valve plate 7 can cover the admission channel 5a to the extent that, between the valve plate 7 and the damping valve body 1a, a passage restriction, or choke 11 can be formed in the vicinity of the admission channel 5a.

This restriction, or choke 11 can essentially have an influence on the operation of the valve 15, by controlling the amount of fluid which passes through the passage 5a, and thus, the pressure acting on the valve discs 13. By selecting the outside diameter 7b of the valve plate 7, the cross section of the choke 11 can very easily be determined for a specified standard damping valve body 1a. As such, for providing valves 1 having various damping characteristics, valve plates 7 of different diameters can be used on essentially the same standard valve body 1a. Alternatively, or in addition to the various diameters of the valve plates 7, the rigidity of the valve discs 13 could also be varied on the standard valve bodies 1a, as discussed above.

The damping valve 15, on the underside 1c, can preferably be fixed in place against an encircling edge 19 of the damping valve body 1a by means of a fastening rivet 17, which fastening rivet 17 can be driven into the piston rod 3. This method of assembly, and other alternative methods are discussed further herebelow. The damping valve body 1a can preferably be separately connected to the piston rod 3 by means of a crimp 21. As such, the bias, or prestress of the valve discs 13 can be accomplished independently of the tolerances of the series arrangement of the support plate 9, valve plate 7 and the valve body 1a.

FIG. 1b shows a plan view of the damping valve 1 taken along the line Ib-Ib of FIG. 1. FIG. 1b also depicts, by lines Ia-Ia, the view of reference for FIG. 1a. As shown in FIG. 1b, the valve plate 7 can preferably be supported on a web labyrinth system 23. This web labyrinth system 23 essentially determines the surface area of the valve plate 7 which is pressurized when the inflow of fluid is from the underside 1c of the damping valve 1. In other words, because of the essentially minimal surface area provided by the web labyrinth system 23 for contact with valve plate 7, there can be a substantial amount of surface area of the valve plate 7 which can be pressurized by fluid flowing into passage 5b.

The web labyrinth system 23 is preferably made up of web segments 23a and 23b. The web segments 23a are

essentially arranged substantially concentrically inside one another. The web segments **23a** can preferably be connected to one another by means of the webs **23b**, which webs **23b** essentially run substantially radially with respect to the webs **23a**. Thus, by means of the orientation of the segments **23a**, **23b**, the two directional admission channels **5a**, **5b** can be fluidly separated from one another. The size and location of the web segments **23b** are preferably optimized to provide the best possible contact surface for the valve plate **7**, so that the valve plate **7**, under essentially any circumstances, will not be deflected when fluid flow is admitted on the top side **1b** of the damping valve **1**.

The web labyrinth system **23** can also essentially guarantee that there will be no sticking effects between the valve plate **7** and the damping valve body **1a**, as the contact surfaces are essentially minimized. As mentioned above, there are also very large surfaces on the valve plate **7** which are pressurized. Thus, because of the large surface area which is pressurized and the minimized sticking between the valve plate **7** and the valve body **1a**, an easy, and preferably smooth, opening of the valve plate **7** can be made possible. To essentially guarantee that the two admission channel systems **5a**, **5b** are reliably separated from one another so that no fluid short circuits occur, the valve plate **7** can preferably be larger by a specified dimension **X** than a neighboring outside diameter **5b'** of the pressurized surface on the valve plate **7**.

As shown in FIG. **1b**, a width **B** of the admission channel portions **5aa** and **5ab**, and the average distance **Y** between the outside diameter **7b** of the valve plate **7** and the outside diameter **5a'** of the admission channel **5a** essentially determines the cross section of the choke **11**. As a result of this location of the choke **11** on essentially the largest possible arc of the valve body **1a**, the negative effects of manufacturing tolerances can be reduced to a minimum. In other words, slight variations in the size of the passage **5a** and the diameter of the valve plate **7** will essentially only minimally affect the overall cross sectional area of the passage choke **11**, as compared to possible valves wherein the passage **5a**, and choke **11** are disposed more centrally in the valve body **1a**.

FIGS. **2a** and **2b** show a damping valve **1** as a base valve of a vibration damper (see full illustration in FIG. **13**). Similar to the view shown by FIGS. **1a** and **1b**, FIG. **2a** is a view taken along line **IIa—IIa** of FIG. **2b**, while FIG. **2b** is a view taken along line **IIb—IIb** of FIG. **2a**. As shown, the damping valve body **1a** can be supported on a base **25** of a vibration damper, which base **25** essentially closes a cylinder tube **27** and a container tube **29**, which container tube **29** preferably surrounds the cylinder tube **27**.

The basic construction of the valve **1** illustrated in FIGS. **2a** and **2b** is essentially identical to the valve illustrated in FIGS. **1a** and **1b**, with a few exceptions. In the valve of FIGS. **2a** and **2b**, there is a substantially radial passage **11a** for the admission channel **5a** in the valve body **1a**. In a manner as discussed above, this radial passage **11a** represents a choke **11** for the damping valve **15** on the underside **1c**. This radial passage **11a** can preferably be formed in an outermost web **23a'** of the web labyrinth system **23**, and it can be desirable that only one of the chokes **11** is formed by such a passage **11a**.

In the left hand side of the plan view in FIG. **2b**, a larger diameter valve plate **7** is shown than the valve plate **7** shown in the right hand side. Thus, it can be seen that the larger the valve plate **7**, essentially the smaller the choke **11** to the admission channel **5a**, wherein a valve plate could be

provided which completely closes off the chokes **11** if so desired. As such, only the radial opening **11a**, might be open to the admission channel **5a**, while the remaining chokes **11** could be closed off. In the left hand portion of FIG. **2b**, since the passage **11a** runs essentially radially outwardly to the cylinder **27**, the dimension **Y** would essentially be measured from the edge **7a** of the valve plate **7** to the cylinder **27**, and not to the inner radial edge **5a'** of the outermost web **23a'**.

It can generally be understood that, as the outside diameter **7b** of the valve plate **7** is reduced in size, the dimension **Y** increases, so that the cross section of the choke **11** also increases, that is, for chokes **11** having the same dimension **B**. In essence, since the dimension **X** (FIG. **1b**) must be maintained to prevent short circuits, the valve plate **7** can be reduced in diameter to the point where the choke **11** is maximized, or where the valve plate **7** extends only slightly beyond a next-outermost web **23d**.

As shown in FIG. **2b**, a multiplicity of chokes **11** can also be used, that is, the chokes **11** can be of various sizes, wherein one of the chokes could have the radial passage **11a**. As a result of the different choke cross sections, the damping valve **1** can be tuned very precisely to achieve a specified damping force characteristic. It is particularly advantageous if the smallest choke cross section which achieves the greatest damping action at the maximum speeds, but which is thereby very sensitive to manufacturing tolerances, is formed by a single choke, so that the tolerance defects of the one choke do not accumulate with the tolerance defects of other chokes. The tolerance of the outside diameter **7b** can thereby be kept small.

Because of the configuration of the webs **23a**, **23b**, the admission channels **5a**, **5b** can be designed so that they are very close to one another without the danger of the occurrence of a hydraulic short circuit in which damping medium bypasses the valve plate **7** and there is communication between the admission channels **5a**, **5b**. Dimensional limits are set essentially only by the contact surfaces (dimension **X**) for the valve plate **7** which separate the flow directions from one another.

It should also be noted that in this embodiment, the web system **23** can also preferably provide additional, separate support surfaces **23c**, which are designed to prevent a deflection of the valve plate **7**.

In FIGS. **3a** and **3b**, wherein view **3a** is a cross section taken along line **IIIa—IIIa** of FIG. **3b**, the damping valve body **1a** is shown as an isolated part. Because there is a multiplicity of choke cross sections **11**, the pressurized surfaces, in particular of the outer web circumferential area **23d**, can be set relatively far out radially, so that there is an optimally large pressurizable surface for the valve plate **7**. In this embodiment, too, the web labyrinth system **23** has concentrically-oriented web segments **23a** which separate the admission channels **5a**, **5b** from one another by means of webs **23b** which run radially. The admission channels **5a**, **5b** for both directions of flow can thereby be located on a common arc, or at least on arcs which are very close to one another.

In the depicted embodiments of FIGS. **1b**, **2b** and **3b**, it can essentially be seen that the webs **23a** and **23b** essentially completely surround the passages **5a**, in the immediate vicinity of the passages **5a**, that is, essentially immediately adjacent the passages **5a**. As such, the radial dimension and circumferential dimension of the passages **5a** can preferably be minimized, thereby enabling the fluid flowing through passages **5b** to come into preferably maximal contact with the underside of the valve plate **7**. With the arrangement as

11

shown, it can be possible to provide at least about twenty-five percent of the cross-sectional area of the piston with passages fluidly open to passages 5b. As such, at least about 30% of the surface area of the underside of the valve plate 7 can be pressurized by fluid from the bottom of the piston. By providing alternative configurations of the webs 23a and 23b, it could essentially be possible to enable up to about 50% pressurization of the underside of the valve plate 7.

As shown in FIG. 3b, there can preferably be radial cuts 8 in some of the webs 23a to thereby allow flow of fluid from passages 5b into the inner areas 10 within the web labyrinth system 23. In essence, while it is desirable to maximize the surface of valve plate 7 which is available to be pressurized by fluid from the underside 1c, a compromise must be made with the amount of support provided for supporting the valve plate 7 against a pressure of fluid from the top side 1b. If insufficient support was provided by webs 23a, 23b, 23d, it might be possible that the valve plate 7 would deform downwardly into spaces between the webs, whereby such downward deformations might give rise to adjoining upward deformations which would cause a fluid short circuit between passages 5a and 5b, thereby rendering the valve inoperative. For this reason, the so-called "labyrinth" arrangement has been found to be appropriate and sufficient for providing maximal surface area for being pressurized, while also providing sufficient support against deformations of the valve plate 7.

In the depicted embodiment of FIGS. 1a and 1b, wherein the vibration damper might have a diameter of about 88.5 mm, the outer radius of the passages 5b is about 33.5 mm, and the outer radius of passages 5a is about 37 mm. As such, allowing about 1 mm for overlap dimension X, this leaves about 2.5 mm available for dimension Y. As such, the radius of valve plate 7 can then preferably be varied between about 34.5 mm to about 37 mm to provide variable damping characteristics of the valve of FIGS. 1a and 1b. In the same scale, the dimension B is depicted as being about 9 mm. Thus, the cross-sectional area of passage portions 5aa and 5ab can essentially be between about 0 mm to about 22.5 mm. These dimensions are essentially meant as exemplary, and it should be understood, that one of ordinary skill in the art would readily be able to configure the dimensions X, Y and B, accordingly for vibration dampers having other diameters, etc., as such dimensions could be appropriately kept to the same proportions as provided hereabove. In addition, variations on the proportions of the dimensions could also be readily made depending on the desired damping characteristics to be achieved.

In the depicted embodiment of FIGS. 1a and 1b, essentially all of the components of the valve 1 have a rotational symmetry, with the symmetry of the valve body being repeated at about 90° intervals. As such, during assembly, there would essentially not need to be any rotational alignment operations, and the parts would essentially only need to be aligned axially for insertion of one part onto, or into another. Even in the embodiment of FIG. 3b, wherein one of the chokes 11 is provided with the radial passage 5a, there would still essentially not need to be any rotational alignment, as the circular valve plate 7 would essentially cover the same amount of the chokes 11 in every possible orientation of the valve plate 7 on the valve body 1a. Thus, assembly of the valve 1 can essentially be simplified.

One feature of the invention resides broadly in the damping valve, in particular for a vibration damper, comprising a damping valve body which has at least one admission channel for each direction of flow, which admission channel connects a top side and a bottom side of the damping valve

12

body to one another, a valve plate on a valve seat surface, whereby the valve plate can lift up off the valve seat surface, and a choke inside the connection path between the top side and the underside of the damping valve, characterized by the fact that the cross section of the choke 11 is defined by the width of an inflow opening of the admission channel 5a and the average radial distance Y between an edge 7a, 7b which defines the valve plate contour and the inflow opening.

Another feature of the invention resides broadly in the damping valve characterized by the fact that the choke 11 is located in the vicinity of the outside diameter of the damping valve body 1a, whereby the outside diameter 7b of the valve plate 7 determines the cross section of the choke.

Yet another feature of the invention resides broadly in the damping valve characterized by the fact that the valve plate 7 is made elastic as a solid disc, and is fixed on the inside diameter 7a.

Still another feature of the invention resides broadly in the damping valve characterized by the fact that the valve seat surface is formed by a web labyrinth system 23 which separates the admission channels 5a, 5b of the two directions of flow from one another.

A further feature of the invention resides broadly in the damping valve characterized by the fact that the web labyrinth system 23 consists of concentrically-oriented web segments 23a, which have radially-running web segments 23b to separate the directional admission channels.

Another feature of the invention resides broadly in the damping valve characterized by the fact that the damping valve 1 has a multiplicity of chokes 11.

Yet another feature of the invention resides broadly in the damping valve characterized by the fact that the maximum choke cross section is achieved when the outside diameter 7b of the valve plate 7 comes into contact with the outermost circumferential web 23d which defines the discharge region for the reverse direction of flow.

Still another feature of the invention resides broadly in the damping valve characterized by the fact that the web labyrinth system 23 has a radial opening 11a which acts as the choke.

A further feature of the invention resides broadly in the damping valve characterized by the fact that the cross sections of at least two chokes 11 are of sizes which are different from one another.

FIG. 4 illustrates a shock absorber 1' which preferably includes an external tube 4', a piston 3' fastened to a piston rod 2', and the fastening devices 5' which are preferably fastened to the piston rod 2' and to the external tube 4'.

The piston 3' illustrated in FIGS. 5 and 5a essentially includes a valve body 7', which valve body 7' is preferably provided with passages 8a/8b', one for each direction of flow. The passages 8a/8b' are preferably covered at their outlet openings by valve discs 6'. These passages 8a' and 8b' can essentially be similar to the passages 5a and 5b as discussed above with reference to FIGS. 1a, 1b, etc. Depending on the desired damping force setting, valve disc packets or stacks can also be used, whereby valve discs of various thicknesses, graduated diameters or advance opening cross sections can preferably be set inside the packet.

The piston 3' is preferably guided or centered by a journal 9', which journal 9' is a component of the piston rod 2'. A supporting ring 11a' is preferably supported on a shoulder 10' of the piston rod 2', and is preferably adjacent to a series of components consisting essentially of the valve disc packet 6', the valve body 7', a throttle disc 12' and an additional

supporting ring 11b'. Preferably, by means of a positive fit 13', the piston 3' is fastened to the piston rod 2'.

The fastening of the piston 3' to the piston rod 2' is preferably achieved by means of a bead 14'. For this bead 14', a blind hole 15' is preferably worked into the journal 9'. This blind hole 15' can advantageously have an overlap 16' with the valve body 7'. During the forming process, which forming process can preferably be forging or possibly cold-forging, an additional axial force component is preferably applied, and a compensation of play between the valve body 7' and the journal 9' is thereby achieved by means of bearing forces in the vicinity of the overlap 16', so that the valve body 7' is preferably fixed on all sides.

In other words, as axial force is applied by a suitable tool during forming, the diameter 9a' (see FIG. 5a) of journal 9' is preferably expanded so that any play between the journal 9' and the valve body 7' is substantially decreased, or possibly eliminated. The forming tool is preferably forced into blind hole 15', thereby expanding the walls of journal 9' and simultaneously forming the beads 14'. Thus, the fit between journal 9' and valve body 7' is preferably much tighter than the fit which is typically achieved by a conventional nut arrangement (i.e. a nut threaded onto journal 9'). Thus, any rattles which can be caused by the contact between journal 9' and valve body 7' can preferably be substantially reduced, or eliminated. Further, the present invention essentially permits the valve body 7' to be centered on the journal 9' more accurately, since essentially all play between valve body 7' and journal 9' can be eliminated.

Generally, during the forming process, the journal 9' will preferably expand substantially equally all around its circumference, thereby grasping the valve body 7' of the piston 3' preferably on all sides. The end result is preferably a "mushroomed" shape.

The supporting rings 11a' and 11b', preferably located inside and outside the row of axially braced components, also each preferably perform an additional function. For example, the supporting ring 11a' preferably has a fastening surface 17' as an additional measure to secure a piston ring 18', which piston ring 18' is preferably guided essentially without undercutting, i.e. in this case by means of two contact surfaces 19a' and 19b' on the valve body 7'. With regard to the supporting ring 11b', it should be noted that the ring 11b' preferably has a rolling contour which can be used to influence the damping force characteristic. In this embodiment, the rolling contour is preferably formed by two essentially conical surfaces 20a'/20b'. As a result of this particular shaping process, the damping force characteristic has a progressive curve in the range of higher flow velocities.

Further, in one preferred embodiment as shown in FIG. 5a, the valve body 7' may have two preferably concentric grooves 7a' and 7b'. The grooves 7a' and 7b' may preferably serve to assist in increasing the pressure force generated by passage 8b', since passage 8b' has a relatively small diameter 8c'. The piston 3' may also include a spring body 6a' or possibly a spring valve.

The embodiment illustrated in FIGS. 6 and 6a are essentially distinguished from the embodiment illustrated in FIGS. 5 and 5a in one aspect by the fact that the supporting ring 11a', with its fastening surface 17', is preferably at least partly supported on the end face of the valve body 7'. The fastening surface 17', as well as the contact surfaces 19a' and 19b', preferably form a chamber for the piston ring 18'.

With regard to the piston ring 18', essentially all that needs to be taken into consideration are the contact surface 19a', and the height of the piston ring 18'.

As a variant of the configuration illustrated in FIGS. 5 and 5a, in FIGS. 6 and 6a the throttle disc 12' is preferably shifted toward the supporting ring 11a'.

Thus, the overlap 16' can be preferably significantly increased while retaining the same depth of the blind hole 15', possibly by relocating the throttle disc 12'.

The supporting ring 11b' is also preferably designed so that the decrease in pressure inside the valve occurs over a longer flow distance. The supporting ring 11b', together with the valve body 7', preferably forms an annular gap 21', so that unpleasant flow noises can be suppressed.

To influence the valve characteristic, a return stop 22', preferably in the form of a spring body with a cover disc, can be used, in particular if only small volumes need to be handled in the compression direction.

Of course, it should be understood that the valve design described above can also be employed in a bottom valve. Such a bottom valve may include that shown in FIG. 55 of U.S. Pat. No. 4,650,042, granted to Heinz Knecht et al. on Mar. 17, 1987, or that shown in FIG. 1 of U.S. Pat. No. 4,802,561, granted to Heinz Knecht et al. on Feb. 7, 1989.

FIGS. 7 and 7a illustrate two embodiments of a piston 103' in a two-tube shock absorber. In FIGS. 7 and 7a, the piston 103' is illustrated in cross section, whereby on the piston rod 102' there is a preferably cylindrical component 108', which cylindrical component 108' in this embodiment is configured as a journal of the piston rod 102'. The cylindrical component 108' preferably holds, in the axial direction, the valve disc 106a' and the valve body 107'. The fastening element 109' is preferably pushed onto the cylindrical component 108', and an appropriate prestress is applied. After the application of the corresponding prestress, the fastening of the fastening element 109' preferably to the cylindrical component 108' can be accomplished in the form of a weld joint, e.g. by laser welding, in spots or alternatively over the entire circumference. The two embodiments shown in FIGS. 7 and 7a preferably illustrate an all-around weld seam 109b' and a spot weld 109a' respectively. When an all-around weld seam 109b' is used, the fastening element 109' can preferably be in the form of a sleeve as shown in FIG. 7. If, on the other hand, a spot weld 109a' is used, the fastening element 109' can preferably be in the form of a pot-shaped component as shown in FIG. 7a.

Thus, if a spot weld 109a' is employed, the strength of the fastening element may preferably be increased by including a bottom portion 109c'. Thus, the fastening element preferably has the form of a "pot".

The embodiments illustrated in FIGS. 7 and 7a show that the valve body 107' and the valve discs 106a' are already fastened to the cylindrical component by means of a riveted joint 115'. In an additional assembly step, the valve discs 106b' are preferably prestressed and fastened.

Also shown in FIGS. 7 and 7a are passages 107a' and 107b', one preferably for each direction of flow. The piston 103', in one embodiment thereof, may also include a valve 107c', which valve 107c' may serve to regulate or control the flow through passages 107a' and 107b'. The passages 107a' and 107b', can generally be considered to be similar to the passages 5a and 5b as discussed above with reference to FIGS. 1a and 1b, etc.

FIGS. 8 and 8a illustrate a piston 103' of a shock absorber, in which the cylindrical component 108' is preferably provided with a hole 110'. A sphere can preferably serve as the expander element 111', and is inserted into this hole 110', so that a positive fit is preferably produced by means of the projections 112' and recesses 113', and by the expansion of

the cylindrical component **108'** preferably as a result of the pressure exerted by the expander element **111'**. This spherical closure illustrated in FIGS. 7 and 7a can also preferably be installed essentially without the generation of any chips which can typically be caused by cutting or machining processes. By means of a corresponding device, or suitable tool, a corresponding pre-stress can be applied to the fastening element **109'**, whereby the expander element **111'**, the cylindrical component **108'**, and the fastening element **109'** can then be connected to one another in the respective or desired position. The embodiment illustrated in FIGS. 11a-11d also preferably provided with a riveted joint **115'**.

Passages **107a'** and **107b'** are shown in the embodiment illustrated in FIG. 8a, one passage preferably for each direction of flow. The piston **103'**, in one embodiment may also have a valve **107c'** which valve **107c'** can serve to regulate the flow through passages **107a'** and **107b'**. The passages **107a'** and **107b'** and the valve **107c'** are generally well-known to those of ordinary skill in the art and will not be discussed further here.

FIGS. 9 and 9a show a fastening element **109'** preferably made of light metal or light metal alloy, which fastening element **109'** has preferably been shrink-fitted in an essentially contactless manner onto the cylindrical component **108'**. The groove **116'** of the cylindrical component is thereby preferably used to achieve the positive fit.

The type of fastenings illustrated in FIGS. 9 and 9a may also conceivably be accomplished by a compression fitting of fastening element **109'** onto cylindrical component **108'**. In this type of fastening, a suitable tool can preferably be used to grasp fastening element **109'** and by compression, force fastening element **109'** onto cylindrical component **108'**.

As shown in FIG. 9a, one embodiment of the present invention may include the valve body **107'** having passages **107a'** and **107b'**, one preferably for each direction of flow. The piston **103'** may also include a valve **107c'**, which valve **107c'** can preferably serve to regulate or control the flow through passages **107a'** and **107b'**. The passages **107a'** and **107b'**, and valve **107c'** can generally be considered to be similar to the passages 5a and 5b and the valve components 7 and 9 as discussed above with reference to FIGS. 1a and 1b, etc.

FIGS. 10 and 10a illustrate an additional type of connection, whereby a cylindrical component **114'** is preferably housed in the hole **110'** of the cylindrical component **108'**. After the prestress has preferably been applied by means of the cylindrical component **114'** on the valve discs **106b'**, the fastening can be realized, for example, by means of a laser weld **117'**. The shoulder **118'** preferably reduces the distance from the outside to the weld point **117'**, or in different embodiments the shoulder **118'** can preferably be used to achieve a distance which is preferably approximately equal along the circumference of the cylindrical component **108'**.

As shown in FIG. 10a, one embodiment of the present invention may include the passages **107a'** and **107b'** of the valve body **107'**. The piston **103'** may also include a valve **107c'**.

FIGS. 11a-11d illustrate one example of the sequence of an automatic assembly process. In FIG. 11a, valve discs **106a'** and the valve body **107'** are preferably threaded onto the piston rod **102'**, which are then (FIG. 11b) preferably connected together by means of the riveted joint **115'**. The valve discs **106b'** are then (FIG. 11c) preferably assembled with the cylindrical element **114'**. After the application of a prestress (FIG. 11d), the fastening is preferably performed, e.g. by means of the weld **117'**.

FIGS. 12 and 12a illustrate a bottom valve, in which bottom valve once again the valve discs **106'** and the valve body **107'** are preferably inserted onto the cylindrical component **108'**, and are axially prestressed preferably by means of a fastening element **109'** and fastened by means of a weld joint **108a'** (see FIG. 12a).

Alternatively, this weld joint **108a'** (see FIG. 12a) can preferably be replaced by a positive connection (not shown), in which the fastening element **109'** and the cylindrical component **108'** are preferably connected by means of an expander element **111'**, similar to the one illustrated in FIGS. 8 and 8a, which expander element **111'** is preferably introduced in a hole (not shown) of the cylindrical component **108'**. Here again, it is also possible to shrink fit the fastening element **109'** onto cylindrical component **108'**, similar to the arrangement illustrated in FIGS. 9 and 9a.

Various types of bottom valves in which the present invention may be incorporated in a manner similar to that described with regard to FIGS. 12 and 12a may be disclosed in U.S. Pat. No. 4,802,561 and U.S. Pat. No. 4,650,042, both cited previously herein.

Various types of forming processes which may conceivably be utilized in accordance with the embodiments of the present invention are disclosed in "Metal Forming Fundamentals and Applications", by Altan et al., published by the American Society for Metals in 1983. Pages 8 through 35 describe various forming techniques and methods which may be used to form various components of the present invention.

Various types of forming machines and forming tools which may conceivably be utilized to form various components of the present invention are also discussed in the aforementioned American Society for Metals publication on pages 103, 119, 120, 126, and 174-177. Some examples of forming machines discussed in these pages are screw presses, crank presses, rolling mills, and hammers.

Further, the process of plastic deformation, which process in at least some aspects may apply to the forming of the various components of the embodiments of the present invention, is discussed on pages 45-82 of the aforementioned American Society for Metals publication.

The aforementioned American Society for Metals publication, namely "Metal Forming Fundamentals and Applications", the complete text thereof and the specific pages cited hereinabove, are hereby incorporated by reference as if set forth in their entirety herein.

FIG. 13 shows what could be considered to be a typical shock absorber or vibration damper in which the embodiments of the present invention may conceivably be incorporated. It should be understood that the components discussed hereinbelow with reference to FIG. 13 may essentially be considered to be interchangeable with similar components discussed hereinabove with reference to FIGS. 1 through 12.

FIG. 13 shows an essentially complete shock absorber or vibration damper **200**, a detailed illustration of the valve unit **201** being omitted for the sake of clarity. The oscillation damper **200** essentially includes a pressure pipe **202** in which a piston **203** on a piston rod **204** divides a working space **205** into an upper or piston-rod-side working chamber **211** and a lower working chamber **206**. A bottom valve unit **207** closes the pressure pipe **202** at the lower end thereof. Either the piston and/or the bottom valve may comprise the valve unit as discussed above with regard to the present invention. A fluid path **208** is formed between the pressure pipe **202** and an intermediate pipe **209**, the intermediate pipe

209 being arranged concentrically with respect to the pressure pipe 202. A connecting orifice 210 in the pressure pipe 202 connects the upper working chamber 211 with the fluid path 208.

A compensating chamber 212 is confined between the intermediate pipe 209 and a portion of the pressure pipe 202, on the one hand, and the container tube 216 on the other hand. This compensating chamber 212 is axially limited by a base member 214 and a piston rod guiding and sealing unit 215. The working space 205 is separated by the piston 203 into the upper working chamber 211 and the lower working chamber 206. Both the upper and the lower working chambers are filled with a liquid. The compensating chamber 212 is also filled with damping liquid up to the level L, and possibly contains a pressurized gas above the level L. The bottom valve unit 207 provides communication between the working chamber 206 and the compensating chamber 212. The piston 203 provides communication between the lower working chamber 206 and the upper working chamber 211.

The piston rod 204 can also have a protective sleeve 218 attached thereto to essentially protect the piston rod 204 when the piston rod 204 is withdrawn out of the cylinders.

According to an illustrative example, the oscillation damper works as follows: When the piston rod 204 moves upwardly, a high flow resistance occurs across the piston 203 and a high pressure is generated in the upper working chamber 211. Liquid from the upper working chamber 211 flows through said high flow resistance into the lower working chamber 206. As the piston rod 204 moves outward of the working space 205, the available volume within the working space 205 is increased. Therefore, liquid can flow from the compensating chamber 212 through the bottom valve unit 207 into the lower working chamber 206. The flow resistance through the bottom valve unit 207 is small in this phase of operation. The movement of the piston rod 204 with respect to the pressure pipe 202 is damped.

On inward movement of the piston rod 204 fluid flows from the lower working chamber 206 through the piston 203 into the upper working chamber 211. The flow resistance across the piston 203 is relatively small and the flow resistance across the bottom valve unit 207 is relatively large. Therefore, a considerable pressure exists even within the upper working chamber 211. The volume within the working space 205 is reduced by the piston rod 204 entering into the working space 205. Thus, damping liquid must flow from the lower working chamber 206 through the bottom valve unit 207 into the compensating chamber 212. In this phase of operation the flow resistance through the bottom valve unit 207 is high such that a high pressure occurs within the lower working chamber 206 and also within the upper working chamber 211.

By the connecting orifice 210 and the fluid path 208 the upper working chamber 211 is connected with the compensating chamber 212 via the valve unit 201, which can be housed in a housing 217 attached to the container tube 216. Such valve units are generally well known, and are therefore not discussed in any further detail herein. As long as the valve unit 201 is closed, the bypass established by the connecting orifice 210, the fluid path 208 and the valve unit 201 is also closed. This is the hardest mode of operation of the oscillation damper. When, however, the valve unit 201 is more or less opened, the bypass is also open. As a result thereof the following behavior exists: On upward movement of the piston rod 204 liquid can flow from the highly pressurized upper working chamber 211 not only across the piston 203 providing a high flow resistance but also from the

working chamber 211 through the bypass 210, 208, 201 to the compensating chamber 212. As such, the damping force is reduced.

When the piston rod 204 moves downwards, there exists again a high pressure within the upper working chamber 211, as described above. Therefore, damping liquid can flow from the upper working chamber 211 through the bypass 210, 208, 201 to the compensating chamber 212. This means that the damping liquid which must be expelled from the working space 205 as a result of the reduced volume therein does not only escape through the bottom valve unit 207 to the compensating chamber 212 but can also partially escape through the bypass 210, 208, 201 to the compensating chamber 212. Such, the damping force is again reduced by the open bypass 210, 208, 207. It is to be noted that the direction of flow of the damping liquid through the bypass 210, 208, 207 is the same, both on upward movement and downward movement of the piston rod 204 with respect to the pressure pipe 202. By increasing the flow resistance through the valve unit 201 the damping force can be increased both for upward and downward movement of the piston rod 204, and by increasingly opening the valve unit 201 the damping force can be reduced both for upward movement and downward movement of the piston rod 204. It is possible to selectively open and close the valve unit or to continuously vary the flow resistance through the valve unit 201.

Examples of shock absorber assemblies and components associated therewith, which may be utilized in accordance with the embodiments of the present invention, may be found in the following U.S. Pat. No. 4,986,393, which issued to Preukschat et al. on Jan. 22, 1991; No. 4,749,070, which issued to Moser et al. on Jun. 7, 1988; and No. 4,723,640, which issued to Beck on Feb. 9, 1988.

The appended drawings in their entirety, including all dimensions, proportions and/or shapes in at least one embodiment of the invention, are accurate and to scale and are hereby included by reference into this specification.

All, or substantially all, of the components and methods of the various embodiments may be used with at least one embodiment or all of the embodiments, if more than one embodiment is described herein.

All of the patents, patent applications and publications recited herein, and in the Declaration attached hereto, are hereby incorporated by reference as if set forth in their entirety herein.

The corresponding foreign patent publication applications, namely, Federal Republic of Germany Patent Application No. P 44 04 835.1-12, filed on Feb. 16, 1994, having inventor Hubert Beck, and DE-OS P 44 04 835.1-12 and DE-PS P 44 04 835.1-12, and, if published their published equivalents, are hereby incorporated by reference as if set forth in their entirety herein.

The details in the patents, patent applications and publications may be considered to be incorporable, at applicant's option, into the claims during prosecution as further limitations in the claims to patentably distinguish any amended claims from any applied prior art.

The invention as described hereinabove in the context of the preferred embodiments is not to be taken as limited to all of the provided details thereof, since modifications and variations thereof may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A vibration damper for damping vibrations of a motor vehicle, said vibration damper comprising:

19

a first tubular member, said first tubular member comprising first means for attaching said first tubular member to one of: a wheel suspension and a support structure of the motor vehicle;

said first tubular member defining a first chamber there-within, said first chamber comprising damping fluid therewithin, and said first tubular member defining a longitudinal dimension;

piston rod means, said piston rod means having a first end within said first tubular member and a second end external to said first tubular member, said piston rod means being movable within said first tubular member in a direction along said longitudinal dimension of said first tubular member;

means for attaching said second end of said piston rod means to the other of: the wheel suspension and the support structure of the motor vehicle;

piston means disposed at said first end of said piston rod means, said piston means having a first side disposed adjacent said piston rod means and a second side opposite to said first side, and said piston means dividing said first chamber into a first chamber portion adjacent said first side of said piston means and a second chamber portion adjacent said second side of said piston means;

said piston means comprising:

at least one first passage for permitting fluid flow in one direction from said first chamber portion to said second chamber portion, said first side of said piston means comprising a passage opening of said at least one first passage for permitting fluid flow from said first chamber portion into said at least one first passage, said passage opening comprising a constant opening for permitting fluid flow from said first chamber portion into said at least one first passage, said passage opening having an outer periphery disposed towards said first tubular member and a radially inner edge disposed radially inwardly of said outer periphery;

at least one second passage for permitting fluid flow from said second chamber portion to said first chamber portion, said first side of said piston means comprising a valve seat for said at least one second passage;

a flexible plate disposed at said first side of said piston means, said flexible plate being configured for bending away from said valve seat to open said at least one second passage upon fluid pressure in said second chamber portion being greater than fluid pressure in said first chamber portion, and said flexible plate being configured for sealing against said valve seat to block flow of fluid through said at least one second passage from said first chamber portion to said second chamber portion, said flexible plate having a peripheral edge disposed towards said first tubular member;

said peripheral edge of said flexible plate defining said radially inner edge of said passage opening of said at least one first passage;

said piston means defining a longitudinal axis substantially parallel to said longitudinal dimension of said first tubular member;

said first side of said piston means comprising a plurality of wall portions;

at least a portion of said plurality of wall portions extending from said first side of said piston means in a

20

direction parallel to said longitudinal axis of said piston means;

said plurality of wall portions comprising a plurality of webs;

said plurality of webs each having a thickness, a length, and a height, said thickness being substantially less than said length;

said plurality of webs defining a labyrinth of fluid passages on said first side of said piston means;

a first portion of said labyrinth of fluid passages being in fluid communication with said passage opening of said at least one first passage;

said first portion of said labyrinth of fluid passages comprising at least one passage portion extending from said passage opening of said at least one first passage to said at least one first passage;

a first portion of said plurality of webs defining at least part of said at least one passage portion, said first portion of said plurality of webs each being disposed parallel to a radius of said piston means;

a second portion of said labyrinth of fluid passages being in fluid communication with said at least one second passage; and

each of said plurality of webs comprising means for separating said at least one first passage from said at least one second passage.

2. The vibration damper according to claim 1 wherein: said flexible plate defines a plane transverse to said longitudinal axis of said piston means;

said passage opening of said at least one first passage being disposed substantially in said plane of said flexible plate; and

said outer periphery of said passage opening of said at least one first passage being stationary with respect to said flexible plate.

3. The vibration damper according to claim 2 wherein: said first side of said piston means further comprises a passage opening of said at least one second passage for permitting fluid flow from said at least one second passage into said first chamber portion;

said second portion of said labyrinth of fluid passages being in fluid communication with said passage opening of said at least one second passage;

said first portion of said plurality of webs substantially surrounding both said passage opening of said at least one first passage and said at least one passage portion;

a second portion of said plurality of webs defining said passage opening of said at least one second passage;

said first portion of said plurality of webs comprising rectilinear, planar portions; and

said second portion of said plurality of webs comprising rectilinear, planar portions.

4. The vibration damper according to claim 3 wherein said plurality of webs are the sole separating means for separating said at least one first passage from said at least one second passage.

5. The vibration damper according to claim 4, wherein: said piston means has a peripheral portion disposed towards said first tubular member;

said passage opening of said at least one first passage being disposed in said peripheral portion of said piston means;

said outer periphery of said passage opening of said at least one first passage comprises at least one of:

21

a portion of said first tubular member; and
 an axial projection of said piston means disposed
 between said first tubular member and said passage
 opening of said at least one first passage.

6. The vibration damper according to claim 5, wherein:
 said passage opening of said at least one first passage has
 a radial dimension from said radially inner edge to said
 outer periphery of said passage opening of said at least
 one first passage, and said passage opening of said at
 least one first passage has a circumferential dimension,
 said radial dimension and said circumferential dimen-
 sion substantially defining a cross-sectional size of said
 passage opening of said at least one first passage;
 said peripheral edge of said flexible plate defines a radius;
 and
 said radius of said peripheral edge of said flexible plate
 defines said radially inner edge of said passage opening
 of said at least one first passage with said radial
 dimension of said passage opening of said at least one
 first passage extending from said peripheral edge of
 said flexible plate to said outer periphery of said
 passage opening of said at least one first passage.

7. The vibration damper according to claim 6, wherein:
 said flexible plate comprises a solid disc, said solid disc
 having an elasticity for permitting bending of said disc
 away from said valve seat;
 said solid disc having a central hole therein, and said
 piston rod means being disposed through said central
 hole for mounting said solid disc adjacent said piston
 means;
 said plurality of webs comprise said valve seat;
 said solid disc has a surface area disposed towards said
 piston means;
 said second portion of said labyrinth of fluid passages
 extending from said at least one second passage over a
 substantial portion of said first side of said piston
 means; and
 said plurality of webs being configured to make a sub-
 stantial portion of said surface area of said solid disc
 available to be pressurized by fluid pressure of fluid
 from said second chamber portion flowing through said
 second portion of said labyrinth of fluid passages.

8. The vibration damper according to claim 7, wherein:
 said plurality of webs comprises concentric web portions
 disposed substantially concentrically about said piston
 means;
 said first portion of said plurality of webs interconnecting
 ones of said concentric web portions to separate said at
 least one first passage from said at least one second
 passage;
 said piston means has a cross-sectional area taken sub-
 stantially transverse to said longitudinal axis;
 said second portion of said labyrinth of fluid passages
 comprise at least about 25% of said cross-sectional area
 of said piston means;
 said surface of said solid disc has a cross-sectional area
 taken substantially transverse to said longitudinal axis
 of said piston means; and
 said second portion of said labyrinth of fluid passages
 pressurize at least about 30% of said cross-sectional
 area of said surface of said solid disc.

9. The vibration damper according to claim 8, wherein:
 said at least one first passage comprises a plurality of first
 passages;

22

said at least one second passage comprises a plurality of
 second passages;
 said at least one passage portion comprises a plurality of
 passage portions;
 each of said first passages comprising a passage opening
 on said first side of said piston means;
 each of said second passages comprising a passage open-
 ing on said first side of said piston means;
 each of said passage openings of said first passages has a
 cross-sectional area defined at least partially by said
 radius of said flexible plate;
 said concentric web portions comprise a radially outer-
 most web portion adjoining each of said second pas-
 sages;
 said radially outermost web portion adjoining each of said
 second passages has a radius;
 said solid disc has a minimum radius, said minimum
 radius of said solid disc being greater than said radius
 of said radially outermost web portion adjoining each
 of said second passages;
 said passage openings of each of said first passages have
 a maximum cross-sectional area with said minimum
 radius of said solid disc;
 said plurality of passage portions extend from said first
 passages to at least one of:
 said first tubular member; and
 said axial projection of said piston means disposed
 between said first tubular member and said passage
 opening, said axial projection comprising a radially
 outermost concentric wall portion of said piston
 means; and
 at least one of said passage openings of one of said
 plurality of first passages has a cross-sectional area
 different from said cross-sectional areas of the others of
 said passage openings of said first passages.

10. The vibration damper according to claim 9, wherein:
 said piston means has a central concentric portion dis-
 posed between said peripheral portion and said central
 hole;
 said plurality of first passages comprise four first pas-
 sages, each of said four first passages being disposed
 concentrically with respect to one another within said
 piston means in said central portion of said piston
 means;
 each of said four first passages comprising a correspond-
 ing passage opening disposed radially outwardly of its
 corresponding first passage;
 said plurality of second passages comprise four second
 passages;
 said four second passages being disposed in said periph-
 eral portion of said piston means;
 said four first passages with corresponding passage open-
 ings being disposed interspaced between said four
 second passages and at an angular orientation of about
 90 degrees with respect to one another;
 said four second passages being disposed between ones of
 said four first passages and at an angular orientation of
 about 90 degrees with respect to one another;
 said four first passages comprises one of:
 circumferential slots extending axially through said
 piston means, each of said circumferential slots
 having an arc length of about 50 degrees;
 axial bores extending through said piston means;
 said four second passages comprise circumferential slots
 extending axially through said piston means, each of

23

said second passage circumferential slots having an arc length of about 50 degrees;

said first portion of said plurality of webs comprise, for each of said passage openings of said first passages, first and second substantially parallel web portions defining lateral sides of said passage portions of said first passages;

said piston means additionally comprises:

means for limiting bending of said flexible plate away from said piston means, said means for limiting bending comprising a substantially rigid disc shaped member disposed about said piston rod means adjacent said flexible plate, said flexible plate being disposed between said means for limiting bending and said piston means;

said second side of said piston means comprises at least one additional valve seat of said first passages;

at least one additional flexible plate disposed adjacent said second side of said piston means, said at least one additional flexible plate being configured for bending away from said additional valve seat to open said first passages upon fluid pressure in said first chamber portion being greater than fluid pressure in said second chamber portion, and said at least one additional flexible plate being configured for sealing against said additional valve seat to block flow of fluid through said first passages from said second chamber portion to said first chamber portion, said at least one additional flexible plate having a peripheral edge disposed towards said first tubular member;

said additional valve seat being disposed radially inwardly of said second passages;

said peripheral edge of said at least one additional flexible plate having a radius extending to said additional valve seat;

at least one peripheral seal extending about said piston means to seal between said piston means and said first tubular member to prevent fluid passage between said peripheral portion of said piston means and said first tubular member; and

said piston means, said flexible plate, said plurality of web portions, said first and second passages, said passage openings and said at least one additional flexible plate are all rotationally symmetrical about said longitudinal axis.

11. In a vibration damper of a motor vehicle, a valve for damping fluid flow within the vibration damper, the vibration damper comprising a first tubular member, the first tubular member comprising first means for attaching the first tubular member to one of: a wheel suspension and a support structure of the motor vehicle; the first tubular member having a first end and a second end and defining a first chamber therewithin, the first chamber comprising damping fluid therewithin, and the first tubular member defining a longitudinal dimension; piston rod means, the piston rod means having a first end within the first tubular member and a second end extending through the second end of the first tubular member, the piston rod means being movable within the first tubular member in a direction along the longitudinal dimension of the first tubular member; means for attaching the second end of the piston rod means to the other of: the wheel suspension and the support structure of the motor vehicle; piston means disposed at the first end of the piston rod means, the piston means having a first side disposed adjacent the piston rod means and a second side opposite to the first side, and the piston means dividing the first chamber into a first chamber portion adjacent the first side thereof and

24

a second chamber portion adjacent the second side thereof; a second tubular member disposed concentrically about the first tubular member, the second tubular member defining a second fluid chamber between the first and second tubular members, said valve comprising:

a valve body, said valve body having a first side and a second side;

means for damping fluid flow between one of: said first and second chamber portions; and said first and second chambers;

said means for damping fluid comprising:

at least one first passage for permitting fluid flow in one direction from said first side of said valve body to said second side of said valve body, said first side of said valve body comprising a passage opening of said at least one first passage for permitting fluid flow from said first side of said valve body into said at least one first passage, said passage opening comprising a constant opening for permitting fluid flow from said first side of said valve body into said at least one first passage, said passage opening having an outer periphery and a radially inner edge disposed radially inwardly of said outer periphery;

at least one second passage for permitting fluid flow from said second side of said valve body to said first side of said valve body, said first side of said valve body comprising a valve seat for said at least one second passage;

a flexible plate disposed at said first side of said valve body, said flexible plate being configured for bending away from said valve seat to open said at least one second passage upon fluid pressure at said second side of said valve body being greater than fluid pressure at said first side of said valve body, and said flexible plate being configured for sealing against said valve seat to block flow of fluid through said at least one second passage from said first side of said valve body to said second side of said valve body, said flexible plate having an outer peripheral edge;

said outer peripheral edge of said flexible plate defining said radially inner edge of said passage opening of said at least one first passage;

said valve body defining a longitudinal axis extending between said first and second sides thereof;

said first side of said valve body comprising a plurality of wall portions;

at least a portion of said plurality of wall portions extending from said first side of said valve body in a direction parallel to said longitudinal axis of said valve body;

said plurality of wall portions comprising a plurality of webs;

said plurality of webs each having a thickness, a length, and a height, said thickness being substantially less than said length;

said plurality of webs defining a labyrinth of fluid passages on said first side of said valve body;

a first portion of said labyrinth of fluid passages being in fluid communication with said passage opening of said at least one first passage;

said first portion of said labyrinth of fluid passages comprising at least one passage portion extending from said passage opening of said at least one first passage to said at least one first passage;

a first portion of said plurality of webs defining at least part of said at least one passage portion, said first

25

portion of said plurality of webs each being disposed parallel to a radius of said valve body;
 a second portion of said labyrinth of fluid passages being in fluid communication with said at least one second passage; and
 each of said plurality of webs comprising means for separating said at least one first passage from said at least one second passage.

12. In a vibration damper, the valve according to claim 11 wherein:

said flexible plate defines a plane transverse to said longitudinal axis of said valve body;

said passage opening of said at least one first passage being disposed substantially in said plane of said flexible plate; and

said outer periphery of said passage opening of said at least one first passage being stationary with respect to said flexible plate.

13. In a vibration damper, the valve according to claim 12 wherein said plurality of webs are the sole separating means for separating said at least one first passage from said at least one second passage.

14. In a vibration damper, the valve according to claim 13 wherein:

said first side of said valve body further comprises a passage opening of said at least one second passage for permitting fluid flow from said at least one second passage to said first side of said valve body;

said second portion of said labyrinth of fluid passages being in fluid communication with said passage opening of said at least one second passage;

said first portion of said plurality of webs substantially surrounding both said passage opening of said at least one first passage and said at least one passage portion;

a second portion of said plurality of webs defining said passage opening of said at least one second passage;

said first portion of said plurality of webs comprising rectilinear, planar portions; and

said second portion of said plurality of webs comprising rectilinear, planar portions.

15. In a vibration damper, the damping valve according to claim 14, wherein:

said plurality of webs comprise said valve seat;

said flexible plate has a surface area disposed towards said valve body;

said second portion of said labyrinth of fluid passages extend from said at least one second passage over a substantial portion of said first side of said valve body; and

said plurality of webs being configured to provide a substantial portion of said surface area of said flexible plate available to be pressurized by fluid pressure of fluid from said second side of said valve body flowing through said second portion of said labyrinth of fluid passages.

16. In a vibration damper, the damping valve according to claim 15, wherein:

said plurality of webs comprise concentric web portions disposed substantially concentrically about said valve body;

said first portion of said plurality of webs interconnecting ones of said concentric web portions to separate said at least one first passage from said at least one second passage;

26

said valve body has a cross-sectional area taken substantially transverse to said longitudinal axis;

said second portion of said labyrinth of fluid passages comprise at least about 25% of said cross-sectional area of said valve body;

said surface of said flexible plate has a cross-sectional area taken substantially transverse to said longitudinal axis of said valve body; and

said second portion of said labyrinth of fluid passages pressurize at least about 30% of said cross-sectional area of said flexible plate.

17. In a vibration damper, the damping valve according to claim 16, wherein:

said passage opening of said at least one first passage has a radial dimension from said radially inner edge to said outer periphery of said passage opening of said at least one first passage, and said passage opening of said at least one first passage has a circumferential dimension, said radial dimension and said circumferential dimension substantially defining a cross-sectional size of said passage opening of said at least one first passage;

said outer peripheral edge of said flexible plate defines a radius; and

said radius of said outer peripheral edge of said flexible plate defines said radially inner edge of said passage opening of said at least one first passage with said radial dimension of said passage opening of said at least one first passage extending from said outer peripheral edge of said flexible plate to said outer periphery of said passage opening of said at least one first passage.

18. In a vibration damper, the damping valve according to claim 17, wherein:

said valve body is configured for being disposed within the first tubular member;

said valve body has a peripheral portion disposed radially outwardly towards the first tubular member;

said passage opening of said at least one first passage being disposed in said peripheral portion of said valve body;

said outer periphery of said passage opening of said at least one first passage is formed by at least one of:
 the first tubular member; and
 an axial projection of said valve body disposed between the first tubular member and said passage opening of said at least one first passage.

19. The damping valve according to claim 18, wherein:

said flexible plate comprises a solid disc, said solid disc having an elasticity for permitting bending of said solid disc away from from said valve seat;

said at least one first passage comprises a plurality of first passages;

said at least one second passage comprises a plurality of second passages;

said at least one passage portion comprises a plurality of passage portions;

each of said first passages comprises a passage opening on said first side of said valve body;

each of said second passages comprises a passage opening on said first side of said valve body;

each of said passage openings of said first passages has a cross-sectional area defined at least partially by said radius of said flexible plate;

said concentric web portions comprise a radially outermost web portion adjoining each of said second passages;

27

said radially outermost web portion adjoining each of said second passages has a radius;

said solid disc has a minimum radius, said minimum radius of said solid disc being greater than said radius of said radially outermost web portion adjoining each of said second passages;

said passage openings of each of said first passages have a maximum cross-sectional area with said minimum radius of said solid disc;

said plurality of passage portions extend from said first passages to at least one of:

the first tubular member; and

said axial projection of said piston means disposed between the first tubular member and said passage opening, said axial projection comprising a radially outermost concentric wall portion of said valve body; and

at least one of said passage openings of one of said plurality of first passages has a cross-sectional size different from said cross-sectional size of the others of said passage openings of said first passages.

20. The damping valve according to claim **19**, wherein:

said valve body has a center;

said valve body has a central concentric portion disposed between said peripheral portion and said center;

said plurality of first passages comprise four first passages, each of said four first passages being disposed concentrically with respect to one another within said valve body in said central portion of said valve body;

each of said four first passages comprising a corresponding passage opening disposed radially outwardly of its corresponding first passage;

said plurality of second passages comprise four second passages;

said four second passages being disposed in said peripheral portion of said valve body;

said four first passages with corresponding passage openings being disposed interspaced between said four second passages and at an angular orientation of about 90 degrees with respect to one another;

said four second passages being disposed between ones of said four first passages and at an angular orientation of about 90 degrees with respect to one another;

said four first passages comprises one of:

circumferential slots extending axially through said valve body, each of said circumferential slots having an arc length of about 50 degrees;

axial bores extending through said valve body;

said four second passages comprise circumferential slots extending axially through said valve body, each of said

28

second passage circumferential slots having an arc length of about 50 degrees;

said first portion of said plurality of webs comprise, for each of said passage openings of said first passages, first and second substantially parallel wall portions defining lateral sides of said passage portions of said first passages;

said valve body additionally comprises:

means for limiting bending of said flexible plate away from said valve body, said means for limiting bending comprising a substantially rigid disc shaped member disposed adjacent said flexible plate, said flexible plate being disposed between said means for limiting bending and said valve body;

said second side of said valve body comprises at least one additional valve seat of said first passages;

at least one additional flexible plate disposed adjacent said second side of said valve body, said at least one additional flexible plate being configured for bending away from said additional valve seat to open said first passages upon fluid pressure at said first side of said valve body being greater than fluid pressure at said second side of said valve body, and said at least one additional flexible plate being configured for sealing against said additional valve seat to block flow of fluid through said first passages from said second side of said valve body to said first side of said valve body, said at least one additional flexible plate having a peripheral edge disposed towards the first tubular member;

said additional valve seat being disposed radially inwardly of said second passages;

said peripheral edge of said at least one additional flexible plate having a radius extending to said additional valve seat;

at least one peripheral seal extending about said valve body to seal between said valve body and the first tubular member to prevent fluid passage between said peripheral portion of said valve body and the first tubular member;

said valve body, said flexible plate, said plurality of web portions, said first and second passages, said passage openings and said at least one additional flexible plate are all rotationally symmetrical about said longitudinal axis; and said valve body comprises one of:

a piston valve for being disposed in, or forming a body of said piston means for damping fluid flow between said first and second chamber portions; and

a bottom valve for being disposed at said first end of the first tubular member for damping fluid flow between said first chamber and said second chamber.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,595,269
DATED : January 21, 1997
INVENTOR(S) : Hubert BECK


It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the title page, item [57], line 4 under the "ABSTRACT" section, after 'channel', delete "connectes" and insert --connects--.

In column 8, line 55, after the first occurrence of 'FIG.', delete "1." and insert --1a.--.

Signed and Sealed this
Twenty-ninth Day of April, 1997

Attest:



BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks